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THESIS

COMPUTER GRAPHICS ADAPTATION
OF SEVERAL AERODYNAMIC
PREDICTION PROGRAMS

by

Craig M. MacAllister

December 1989

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This thesis describes the adaptation of six computer programs on the Micro VAX/2000/CAD/CAE work-station. Three of the programs, NEW_DOUBLE, NEW_PANEL, and NEW_VOR, were originally transferred to the Aeronautical Engineering VAX System Server by LCDR John Campbell. Two of the programs (SUB and SUPER), both vortex lattice method programs, were placed in the VAX system by Mr. Rich Margason of the Langley Research Center. The sixth program, a viscous interaction program was transferred/adapted to the VAX system by the author of this report. Extensive modifications were made to these programs to enhance their user interface. In addition, each program has been adapted to provide interactive graphical/printed output. Furthermore, program NEW_DOUBLE was modified to accept any arbitrary symmetrical shaped body. Lastly, NEW_PANEL was altered to interface with the viscous interaction program in which boundary layer characteristics were determined. All user inputs in NEW_DOUBLE, NEW_PANEL and NEW_VOR were also backed up with interactive checking routines. The programs were intended to be used by aeronautics/astronautics engineering students in basic and advanced courses in aerodynamics.

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Computer Graphics Adaptation of Several Aerodynamic Prediction Programs

by

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ABSTRACT

This thesis describes the modification of six computer programs on the Micro VAX/2000/CAD/CAE workstation. Three of the programs, NEW_DOUBLE, NEW_PANEL, and NEW_VOR, were originally transferred to the Aeronautical Engineering VAX System Server by LCDR John Campbell. Two of the programs (SUB and SUPER), both vortex lattice method programs, were placed in the VAX system by Mr. Rich Margason of the Langley Research Center. None of the above five programs had any graphics facility. The sixth program, a viscous interaction program was transferred/adapted to the VAX system by the author of this report. Extensive modifications were subsequently made to these programs to enhance their user interface. In addition, all the programs have been adapted to provide interactive graphical/printed output. Furthermore, program NEW_DOUBLE was modified to accept any arbitrary symmetrical shaped body. Lastly, NEW_PANEL was altered to interface with a viscous interaction effects program in which the boundary layer characteristics are determined. All user inputs in NEW_DOUBLE, NEW_PANEL and NEW_VOR were backed up with interactive checking routines. The programs are intended to be used by aeronautics/astronautics engineering students in basic and advanced courses in aerodynamics.

THESIS DISCLAMER

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First and foremost, I would like to thank the members of my family for their unwavering support of my thesis efforts. Secondly, I would like to thank Professor Val Healey, who provided me with the topic for this thesis and who helped me to understand the underlying principles of computational fluid dynamics. Additionally, I would like to thank both Professor Healey and Professor Platzer for affording me several opportunities to have their students test and help in the development of these computer programs. The comments of their students greatly assisted me in improving the user interface characteristics of these programs. Furthermore, I would like to thank Mr. Edward Ward, Ms. Donna Byrch and Mrs. Karen Yates for transferring my FORTRAN files from my VAX lab account to my IBM mainframe account. Their efforts greatly facilitated the final editing of my programs. Lastly, a special note of thanks goes to Mr. Tony Cricelli and Mr. Dave Marco for the benefit of their technical expertise in using the VAX system.

I. INTRODUCTION

Incorporated in this thesis are six FORTRAN programs which have been extensively modified to improve their user interface and to enhance their output capabilities. Three of the programs, NEW_PANEL, NEW_DOUBLE, and NEW_VOR were originally transferred to the Aeronautical Engineering CAD/CAE Lab by LCDR John Campbell. Two of the programs, SUB and SUPER, vortex lattice programs, were developed by NASA AMES and transferred to the CAD/CAE Lab by Mr. Rich Margason. The sixth program, written by Dr. Cebeci, was transferred/adapted by the author of this thesis.

The main focus of this thesis was to adapt the above mentioned programs with a graphic facility. The graphics base program was developed by Mr. Dave Marco of the Mechanical Engineering Department, Naval Postgraduate School. The base program is simply a compilation of FORTRAN subroutines (similar to the popular graphics program DISSPLA) which can be called to effect 2-D graphics. As such, the graphics produced by the aforementioned Computational Fluid Dynamics (CFD) programs are limited to two dimensions. All of the plots generated by the respective program adaptations are effected interactively with little or no user input.

Additionally, the respective program modifications were primarily intended to enhance the user interface with the CFD programs and, in a sense, effectively streamline their use. Specifically, adaptations such as input checking, interactive menus, automatic sorting routines, and backup output data file creation were integrated into each program. To supplement this thesis objective, a concise User's Manual was created to provide the aeronautical engineering student a program reference guide. The user's manual, in fact, details all functional aspects of these programs and provides computational examples supplemented with graphical/tabular results. The User's Manual was geared to the student with little or no experience with the VAX system.

Furthermore, the programs NEW_DOUBLE and NEW_PANEL each received specific adaptations which were not originally within the scope of this thesis. Specifically, the NEW_DOUBLE program, a line doublet distribution program, was adapted to input any symmetrical body. Originally, the NEW_DOUBLE program could only consider an elliptic or a one-family symmetrical airfoil-like shape; this family is described by the equation:

$$Y(x) = A \sqrt{\frac{x}{c}} \quad (c-x)$$

The NEW_PANEL program was adapted to interactively process a coefficient of pressure (Cp) distribution to determine boundary layer characteristics. The source of the Cp distribution to be analyzed can be either from the NEW_PANEL program itself or an arbitrary Cp distribution which can be entered from an input data file.

Thesis results and recommendations for future work are given.

II. PROGRAM ADAPTATION

A. INTRODUCTION

Computer programs can always be improved or enhanced. New programming techniques coupled with improved programming languages provide a limitless number of programming innovations which can be initiated. Additionally, as technological advances occur in the realm of computer hardware, it is without question that software development will also be enhanced.

The first major modification made to all the programs considered in this thesis was to totally restructure and streamline each program to facilitate editing and compiling. As each program was modified, it became excessively large; the main program coupled with all of its subroutines to include the new graphics subroutines invariably exceeded the buffer size of the VAX 2000 Workstation. The base program and each of its subroutines were placed in a separate FORTRAN file. Each FORTRAN subroutine was then compiled as a single entity to create its own object file. The object files of the subroutines were then consolidated into a library file specifically named to support its base program. Prior to running a particular program, the base program object file, the library of subroutine object files and the object file for the graphics program were linked together to create a single executable file.

All of the programs, with the exception of the viscous effects program, were adapted to output 2-D plots. As mentioned in the introduction, the graphics program was created by Mr. Dave Marco and, in its present state, is called DLIB. Again, DLIB is a compilation of graphics subroutines. The version of DLIB used in this thesis is called DISL and represents a small alteration of the original to enhance its interface with the graphics subroutines. Specifically, the DLIB requirement to enter the command of "CONTINUE" once a graphics image is presented on the screen was deleted. The original intent of this requirement was to ensure that the graphics image would not be erased from the screen until the user decided to continue. However, the graphics image created by a FORTRAN subroutine will not disappear until the program execution is terminated. Thus, this command requirement (CONTINUE) was not needed and presented a point of confusion for program users.

The procedure to effect the graphical plots in each program differed to a degree. The principal difference lay in the method in which data arrays were read into the graphics subroutine. However, the use of backup data files was common to all programs. These files not only facilitated the development of the graphics but also acted as a data checking vehicle. The use of common blocks to transfer data arrays between subroutines was kept to a minimum for simplicity's sake. Automatic scaling of data is not standardized across all of the CFD programs. Varying techniques were needed to preclude data array distortion. However, each graphics subroutine contains a FORTRAN "CALL" statement to effect the automatic scaling routine which determined the maximum and minimum values of the data arrays to be plotted.

B. PROGRAM NEW_DOUBLE ADAPTATIONS

The purpose of the NEW_DOUBLE program is to determine the piecewise constant doublet strength, m(t), for a line doublet distribution of an elliptic or symmetrical airfoil-like shapes at zero angle of attack. The points t_i, represent the location of the doublets along the chord or line of symmetry. They are concentrated near the ends of the distribution, using a cosine spacing method, where the variation of the doublet strength is expected to be most rapid. The point t_1 corresponds to x_s and t_N corresponds to the endpoint x_f.

The stream function can be calculated from the doublet strength distribution. From the stream function, the velocity components and the pressure coefficients are then calculated. The surface shape is defined by $y= Y(x)$ and the solution must satisfy zero velocity conditions at the leading and trailing edge stagnation points.

In addition to adding graphics subroutines to this program, NEW_DOUBLE was adapted to analyze any symmetric shape. The user is first required to interactively enter the respective data points for the top portion of the symmetric shape. Once all of the points have been entered, the program will allow the user to correct any mistakes he or she may have made while entering the data. Using a spline routine, the intermediate points along the symmetric shape can be obtained readily to facilitate program processing [Ref. 1]. In brief, the spline routine created a continuous function between each adjacent data point.

The NEW_DOUBLE graphics subroutines (GRAPH1, GRAPH2, GRAPH3) presented several unique features. First of all, the automatic scaling routines are specific to the particular type of plot to be created. Specifically, three automatic scaling routines were created: FIX, SCALER, SCALER2. Each of these routines determined the maximum and the minimum value of the specific array to be plotted. Another unique feature common to the NEW_DOUBLE graphics subroutines is that they were designed to read the data arrays to be plotted from dummy data files which were established in the computational subroutines. This technique facilitated the data checking capability of the program and ensured accurate plots. Lastly, all of the plots were created to produce explanatory remarks to enhance the user's capability to relate the program inputs to the graphical outputs. The graphics subroutines included common blocks which enabled the plots to display user interactive inputs such as the thickness ratio, the maximum thickness, and the number of intervals specified. Typical plots obtained from the NEW_DOUBLE program are provided in Appendix A. [Ref. 2 and 3]

C. PROGRAM NEW_PANEL ADAPTATIONS

The purpose of the original PANEL program was to provide an analysis of the aerodynamics of NACA four-digit airfoils and airfoils of the NACA 230XX family using the source panel method. The program has been modified to accept arbitrary airfoil surface coordinate input and is limited to single-element airfoils. The solution is determined for conditions of incompressible and inviscid uniform free-stream flow. The very small coefficient of drag provided in the results is due to nume' ical round-off error. Furthermore, NEW_PANEL has also been adapted to analyze viscous effects. When considering the viscous analysis loop of the program, it is important to understand that the Cebeci program adaptation is sensitive to flow separation on the airfoil. Boundary layer thickness and other boundary layer characteristics are computed and outputted into a tabular format.

The most dramatic modification made to the NEW_PANEL program was the adaptation of the program to consider viscous effects. The first step in making this modification was to transfer the Cebeci program to a CAD/CAE lab account. The original version of this program was provided by Dr. M. F.

Platzer, Aeronautics/Astronautics Department, Naval Postgraduate School (NPS). The program, written in FORTRAN, had already been adapted for an IBM PC but the user interface with this program was extremely poor and formal instructions on its use did not exist. The program was subsequently manually transferred to a VAX lab account. After an inordinate amount of error checking, the program was validated against a report offered by Dr. Platzer. The Cebeci program was then modified to enhance its user interface by incorporating interactive input requests to include printing options and input source selection. In addition, a common "bubble-sort" FORTRAN routine was added to the Cebeci program to automatically determine the stagnation point on the airfoil [Ref. 4]. The original version of this program required the user to specify this point. Furthermore, the user is required to specify the point at which laminar-turbulent transition occurs on both the top and the bottom of the airfoil as well as the stream-flow Reynolds number. Finally, the Cebeci program was fully integrated with the NEW_PANEL program. The Cp distribution created by the NEW_PANEL method was then interactively sorted, scaled, and inputted into the Cebeci program. This program, as noted above, then computed and outputted the respective boundary-layer characteristics. In addition to the Cp distribution created by NEW_PANEL program, the user can also enter any arbitrary Cp distribution from a data file called BL2D.DAT. This last option allows the user to in effect, conduct viscous effects calculations while not being limited by the program restrictions of NEW_PANEL.

The NEW_PANEL graphics subroutines (GRAF1, GRAF2) presented several unique features. First of all, the automatic scaling routines are specific to the particular type of plot to be created. Specifically, two automatic scaling routines were created: FORM1, FORM2. Each of these routines determined the maximum and the minimum value of the specific array to be plotted. Like NEW_DOUBLE, NEW_PANEL graphics subroutines were designed to read the data arrays to be plotted from dummy data files which were established in the computational subroutines. Again, all of the plots were created to produce explanatory remarks to enhance the user's capability to relate program inputs to graphical outputs. The graphics subroutines included common blocks which enabled the plots to display user interactive inputs such as the number of panels, the angle of attack, and the NACA airfoil number. Another unique feature of the NEW_PANEL graphics subroutines is the addition of the capability to produce two graphs which were not within the scope of the original NEW_PANEL program. Specifically, the relationships of Cm c/4 versus angle of attack and Cl versus angle of attack can be plotted. This adaptation was realized by causing the NEW_PANEL program to perform the NEW_PANEL analysis at 2 degree increments in angle of attack from -8 degrees to 16 degrees. Typical plots obtained from the NEW_PANEL program are provided in Appendix B. [Refs. 2 and 3]

D. PROGRAM NEW_VOR ADAPTATIONS

The purpose of the NEW_VOR program is to provide an application of the vortex lattice method for the determination of the lift distribution of a flat rectangular wing. This method is based on a distribution of discrete horseshoe vortices over a wing surface that has been divided into a finite number of panels. A system of linear equations is developed for the vortex strengths on the panels and solved by matrix methods.

In addition to adapting the NEW_VOR program for printing/graphics options, this program was also modified with a unique subroutine to effect the automatic scaling function. Rather than creating a separate/unique scaling subroutine for each graphical output, a single subroutine (called MAXMIN) was developed to sort the designated array. The MAXMIN subroutine was designed to output the maximum and minimum value in the array, and the particular array in ascending order. In that the array to be plotted was outputted in ascending order, it was necessary to establish a dummy array in each respective graphics subroutine which would be plotted. Otherwise, the plots would invariably ascend from left to right. Again, each plot was adapted to present user inputs. Specifically, the values for aspect ratio and angle of attack are displayed. Typical plots obtained from the NEW_VOR program are provided in Appendix C. [Ref. 2]

E. PROGRAM "SUB" ADAPTATIONS

The SUB program has been adapted from a National Aeronautics and Space Administration (NASA) FORTRAN program which has been used considerably at the Langley Research Center and in industry. The results have shown good correlation with experimental results. SUB has subsequently been revised to enhance it's ease of use and its ability to present accurate graphical results. This particular program has also undergone extensive student evaluations. An AE 2035 class of 14 students thoroughly tested and evaluated the majority of the functions which this particular program offers. As a result of their findings, numerous modifications were made to the program SUB as will be detailed below.

The purpose of the SUB program is to estimate the subsonic aerodynamic characteristics of complex planforms. The program represents a lifting planform with a vortex lattice. A relatively complex planform may be analyzed using up to 24 line segments on a semispan. Additionally, these line segments may have an outboard variable-sweep panel or they may have several dihedral angles across the span. Furthermore, two planforms may be used together to represent a combination of wings and tails or wing, bodies, and tails.

The SUB graphics subroutines (GRAPH1, GRAPH2, GRAPH3) present several unique features. First of all, automatic scaling is again effected by the MAXMIN routine. Secondly, dummy data files were established in the computational subroutines and subsequently read in each graphics subroutine. The use of common blocks was kept to a minimum. The coefficient of pressure data provided by the SUB program lends itself readily to 3-D graphics. However, in the absence of a 3-D graphics program in the CAD/CAE Lab, the program was modified to locate the data at the user specified planform position. Specifically, a sorting routine was developed to allow the user to specify a particular spanwise position on the planform to analyze the Cp distribution across the chord of the planform. In order to create this sorting routine, it was necessary to adapt the data output to the finite difference nodal network. This was simply done by realizing the constant spacing distances between the nodal points (stations). Typical plots obtained from the SUB program are provided in Appendix D. [Ref. 5]

Lastly, the SUB program was modified to provide the user the opportunity to copy the output data file into an alternate data file so that his or her results would be saved for further analysis. Subsequent runs of the program could then be made without losing the results already determined. This modification was effected through interactively allowing the user to select an alternate data file from a list of four files.

F. PROGRAM "SUPER" ADAPTATIONS

The SUPER program has also been adapted from a National Aeronautics and Space Administration (NASA) FORTRAN program and has been used considerably at the Langley Research Center. The use of this program is confined to the supersonic flow regime. In addition, the linearized supersonic lifting surface theory, used in this program, applies to wings having negligible thickness . SUPER has subsequently been revised to enhance it's ease of use and its ability to present accurate graphical plots. These graphical representations have been verified with NASA reports as referenced below.

The purpose of the SUPER program is to estimate the supersonic aerodynamic characteristics of complex planforms. Linearized supersonic lifting surface theory is employed to calculate the aerodynamic characteristics of a warped wing of arbitrary planform. The program calculates lifting pressure distribution for the warped wing at fixed attitude and the pressure distribution (per degree angle of attack) for a corresponding flat wing. These two pressure distributions are combined by superposition principles and integrated over the wing surface to obtain the variation of aerodynamic characteristics with changes in angle of attack.

Similar to the case of program SUB, complex sorting routines were developed to allow the user to specify the respective chordwise or spanwise position on the supersonic planform which would be analyzed for plotting purposes. The coefficient of pressure data provided by the SUPER program also lends itself quite readily to 3-D graphics. Again, in the absence of a 3-D graphics program, the program was modified to locate the data at the user specified planform position. In order to create these sorting routines it was necessary to adapt the data output to the finite difference nodal network. Like program SUB, this was done by realizing the constant spacing distances between the nodal points and subsequently sorting the data accordingly to isolate the requested data. Typical plots obtained from the SUPER program are provided in Appendix E. [Refs. 6 and 7]

Another modification made to the SUPER program concerns its output data file. The output data file for the SUPER program is extremely long. The great length of this file was of negligible utility to the common user. A new output data file was created within the text of the program which simply outputted the input data and the aerodynamic results. The tabular coefficient of pressure data was not incorporated into the output file. However, the full output data file with complete Cp data is still written to a file called "OUTER.DAT". The abbreviated output file (OUTFILE.DAT) greatly facilitates the printing of the output file for the user.

Lastly, like SUB, the SUPER program was modified to provide the user the opportunity to copy the output data file into an alternate data file so that his or her results would be saved for further analysis. The user is given the opportunity to interactively select an alternate data file name in which he or she can store their computational results.

III. SOLUTION FOR THE TWO-DIMENSIONAL INCOMPRESSIBLE LAMINAR AND TURBULENT BOUNDARY LAYER PROBLEM

A. INTRODUCTION

This section relates the numerical methods employed to solve the two dimensional incompressible laminar and turbulent boundary layer problem as conceived by Dr. T. Cebeci and Dr. H. B. Keller. As discussed earlier, this particular boundary-layer solution method was modified and imbedded into the NEW_PANEL program. The intent of this section is to provide a brief synopsis of their problem solution, not a detailed account. The development of the specific theoretical basis/computer code development of the Cebeci program is not within the scope of this thesis [Ref. 8]. In order to use Dr. Cebeci's method, it is necessary to input the potential flow solution over a section shape. In particular, the Cp distribution or the velocity distribution is required. Such information is obtained quite readily through the execution of the NEW_PANEL program. In fact, the Cp distribution is interactively sorted and inputted to the Cebeci program upon the user's request. In addition, one of the functional capabilities of the NEW_PANEL program is to input an arbitrary velocity distribution. Furthermore, the Cebeci program version provided by Dr. M. F. Platzer was further revised to determine the coefficients for skin friction drag and form drag from the computed boundary-layer characteristics. This additional capability was transferred from the original version which is currently available for use on the IBM mainframe at the Naval Postgraduate School, account 4632P.

B. NUMERICAL SOLUTION BASIS

This program uses a finite-difference method to solve the partial differential equation obtained by using the Falkner-Skan transformation of the general boundary layer equations. Both laminar and turbulent flows may be analyzed in that an eddy-viscosity concept has been incorporated into the program which allows the momentum equation for turbulent flows to be written in the same form as a laminar flow. Dr. Cebeci's method is valid except upon the evolution of flow separation. The boundary layer separation point corresponds to the vanishing of the wall shear force at that point. Dr. Cebeci [Ref. 8] states, "if the wall shear vanishes at some x-location during the solution procedure, the solutions break down and convergence cannot be obtained. This is sometimes referred to as the singular behavior of the wall shear close to the separation point." Close inspection of the boundary layer results provided by the NEW_PANEL program is advised in order to ensure that the results are in fact valid. Extremely large values of displacement or momentum thickness indicate flow separation on the shape being analyzed. As an additional note, the program is limited to two dimensions in that negligible transverse curvature has been assumed.

C. COMPUTER PROGRAM NUMERICAL SOLUTION

There exist several methods to solve the boundary-layer equations. The finite difference method used in this program was developed by Dr. H. B. Keller [Ref. 9]. Keller's box method has been used extensively to solve the boundary-layer equations. The first requirement to be effected before the Keller method can be employed is to rewrite the governing equations as a first order system. The resulting first-order equations are subsequently approximated on an arbitrary rectangular net. The finite-difference equations evolve from "centered-difference" derivatives and averaged at the midpoints of the net rectangle. Figure 1 represents the orientation of the net rectangle. The respective nodal points are determined by:

$$E_0=0,\ E_n = E_{n-1} + k_n,\ n = 1,2,3...N$$

$$n_0=0,\ n_j = n_{j-1} + h_j,\ j = 1,2,3...J$$

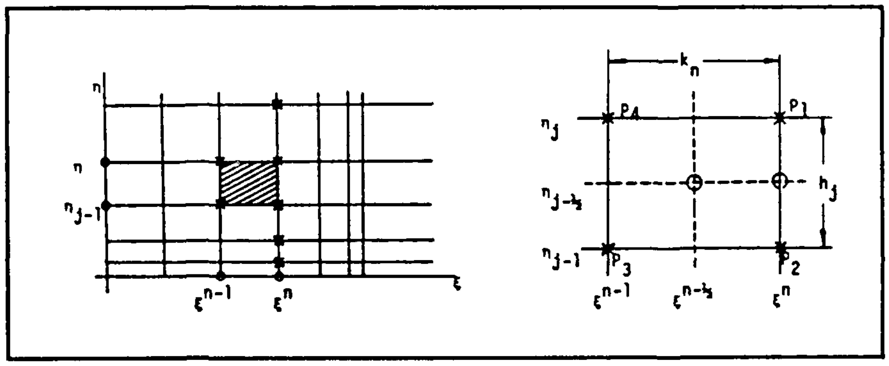


Figure 1. Rectangular Net Orientation, Keller's Box

Solutions of the finite difference equations yield a truncation error of the second order. The difference equations are subsequently linearized by Newton's method [Ref. 9]. Finally, the equations are solved by a block-elimination method [Ref. 8].

The computer program has been broken down into several separate subroutine programs labeled as CIB, COEF, BL, EDDY, SOLV3, OUTPUT, and DRAG. Subroutine CIB is called from the NEW_PANEL main program which in turn calls the remaining subroutines in order to determine the requisite boundary-layer characteristics. The flow transition point (laminar to turbulent) is interactively inputted by the user for both the upper and lower surfaces of the airfoil. The user is also prompted to enter the chord-based Reynolds number.

IV. USER'S MANUAL

In order to facilitate the use of the programs addressed in this thesis, a User's Manual was created which expanded upon the one made by LCDR John Campbell [Ref. 1]. Appendices A through E of this thesis contain the text portions of the User's Manual as well as representative graphical outputs. The User's Manual in its final form is approximately 150 pages long, excluding section and sample problem dividers. The bulk of the User's Manual consists of the output data files, the input data files (if appropriate) and the graphical outputs for each sample problem referenced in the User's Manual. These output files/plots served as the primary basis for validating the graphical plots obtained by each respective program. As an additional note, the User's Manual was not included in this thesis in its entirety due to its extreme length.

V. PROGRAM COMPUTER CODES

Appendices F through J contain the complete source codes of the programs discussed in this thesis. These codes are in their final form. However, it should be noted that each subroutine/main program has been written and presented as a stand-alone FORTRAN program in that each program can be compiled individually. As noted earlier, once each subroutine was compiled, an "object" file was created by the computer. This "object" file was then placed in its respective program library (*DOUBLIB, PANLIB, VORLIB, SUBLIB, SUPLIB*). Prior to running the particular program, the library of "object" files was linked with the object file of the main program (NEW_DOUBLE, NEW_PANEL, NEW_VOR, SUB, SUPER) and with the object file of the graphics program (DISL). Linking the files in this manner created a single executable file for each program.

There exists several lines of FORTRAN code in each individual program which are *currently* not executable (comment lines). Some of these comment lines will facilitate future modifications; others represent routines which were specifically incorporated for data checking; and the remainder are simply comments to clarify the executable statements. Rather than deleting these lines as being extraneous, they were left in the program to facilitate future modifications/program maintenance. These routines are marked appropriately within the program.

VI. RESULTS AND RECOMMENDATIONS

The objectives of this thesis, as originally conceived, have been realized. Five FORTRAN programs (NEW_DOUBLE, NEW_PANEL, NEW_VOR, SUB, SUPER) have been modified to interactively supply graphical representation of the respective computational results. In fact, SUB and SUPER were added to the list of programs to be modified well into the thesis research process. In addition, NEW_DOUBLE can now analyze any symmetrical shape. Data checking routines were also added to NEW_DOUBLE to enhance data input procedures. Furthermore, the user interface capabilities of each program were significantly improved, especially for SUB and SUPER. Lastly, each program was adapted to provide the user the capability to interactively print the computational results or the plots developed.

To enhance the utility of these programs, a concise User's Manual was developed. This manual fully describes each program to include program and input restrictions. In addition, numerous sample problems were integrated into the manual to demonstrate to the user the various capabilities of each program. For each sample problem, detailed instructions are given on how to use the program properly. Furthermore, the output data files and graphical plots created by each sample problem are also included in the User's Manual.

The validation of the graphical results was achieved through several sources; in particular, the books by Ira H. Abbott and A.E. VonDoenhoff [Ref. 10] and by John D. Anderson, Jr. [Ref. 11], were used to check the plots generated by NEW_DOUBLE and NEW_PANEL. LCDR J.A. Campbell's thesis results were used to validate the NEW_VOR plots. In order to check the SUB and SUPER graphs, the NASA publications detailing each respective program were used [Refs. 5, 6, and 7]. In all cases, the graphical representations produced by these programs were qualitatively and quantitatively correct. No arbitrary adjustments were made to the graphics subroutines to "fit" the data to the respective validating source.

Modifications and further adjustments can always be made to a computer program to either enhance or expand its capabilities. As stated earlier, the tabular output of data in SUB and SUPER readily lends itself to 3-D graphics display. At such time that the Aeronautics/Astronautics Department CAD/CAE lab receives a 3-D general graphics package, such as DISSPLA, SUB and SUPER can easily be adapted to produce 3-D plots. The graphics subroutines, as they are currently written, use call statements identical to those used with a DISSPLA package. Furthermore, the data generation required for the respective 3-D plots has already been programmed into the graphics subroutines. An additional modification would be to adapt the Cebeci program output to produce graphical results. Furthermore, the Cebeci program could also be modified to solve a variety of problems including 2-D flows with heat and mass transfer, slot injection as well as axisymmetric flows. Lastly, the programs SUB and SUPER could be adapted to interactively accept the data inputs from the console rather than requiring the user to create an input data file. However, the inputs to both programs can be rather long and detailed in the analysis of a complex planform.

APPENDIX A
PROGRAM NEW_DOUBLE USER'S MANUAL

USER'S GUIDE CONTENTS

I. INTRODUCTION

The purpose of the NEW_DOUBLE program is to determine the piece-wise constant doublet strength m(t) for a line doublet distribution of an elliptic or airfoil-like shape at zero angle of attack. The points t_i, represent the location of the doublets along the chord or line of symmetry. They are concentrated near the ends of the distribution, using a cosine spacing method, where the variation of the doublet strength is expected to be most rapid. The point t_1 corresponds to x_s and t_N corresponds to the endpoint x_f.

The stream function can be calculated from the doublet strength distribution. From the stream function, the velocity components and the pressure coefficients may be calculated. The surface shape is defined by y=Y(x) and the solution must satisfy the zero velocity conditions at the leading and trailing edge stagnation points.

II. ASSUMPTIONS AND LIMITATIONS

The approach taken to develop this method of solution assumes that the doublet strength functions are both piecewise-constant along the chord. It is also important to remember that this solution is valid for incompressible and inviscid uniform freestream flow. Since the bodies under investigation are (two dimensional) symmetrical and at zero angle of attack, there is no lift nor induced drag produced. In addition, there is no drag since we are considering an inviscid fluid and no separation is allowed for.

III. INPUT DESCRIPTION

There are very few input values required for this simple program. Their description and program variable names are listed below.

NTYPE—Type of body shape; elliptic, a single-family airfoil-like, given by

$$Y(x) = A\sqrt{\frac{x}{c}}\ (c-x) \quad , \qquad \text{or symmetric.}$$

TAU— Thickness ratio. (Maximum thickness/chord)

XMAXY— Chordwise location of the point of maximum thickness. (Airfoil only)

N— Number of intervals. $2 \le N \le 100$

XS— Doublet distribution starting point.

XF— Doublet distribution ending point.

NXTOL— Exponent value used to generate the convergence criterion XTOL.

NFTOL— Exponent value used to generate the convergence criterion FTOL.

XTOL— X location tolerance.

FTOL— Function tolerance.

X-X Coordinate of the symmetric shape airfoil surface.

Y-Y Coordinate of the symmetric shape airfoil surface.

IV. SAMPLE PROBLEMS

A few sample problems will illustrate the use of the NEW_DOUBLE program. The first problem will use an ellipse of thickness ratio 0.1. The second problem will analyze an airfoil-like shape with a thickness ratio of 0.12 and a chordwise location of maximum thickness of 0.30. Finally, the third problem will analyze a symmetric shape.

V. STARTING THE PROGRAM

Begin with the screen showing the DCL prompt, which looks like this:

```
$
```

Next, ensure that the program is in your directory by typing:

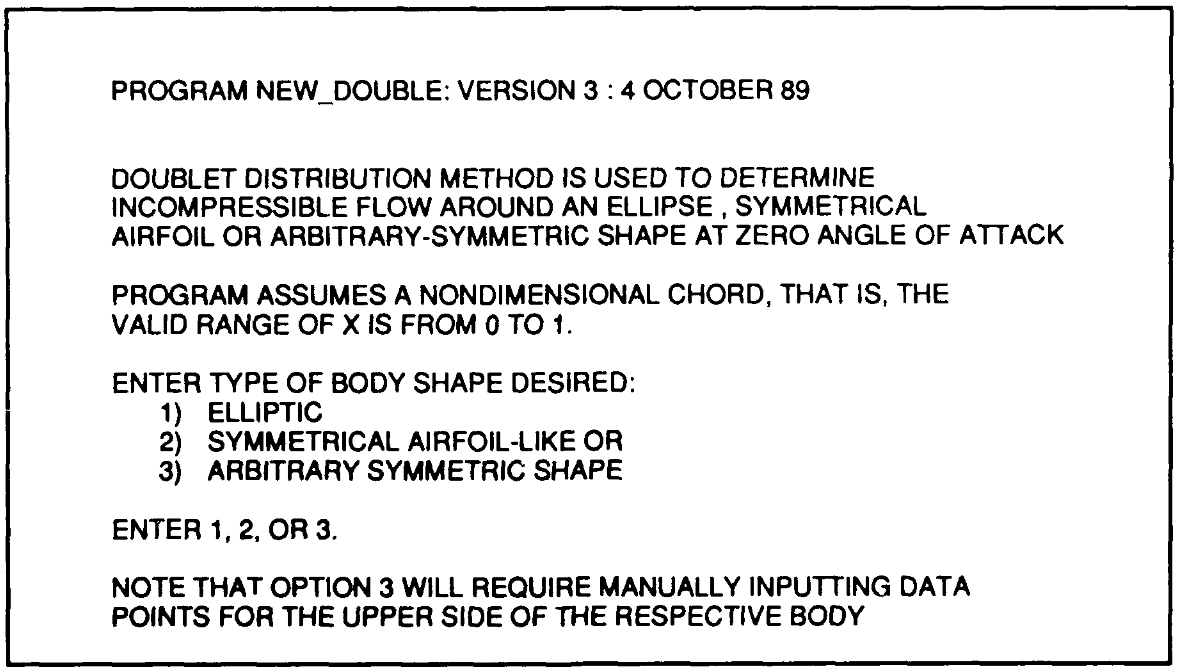
DIR [Return]

and viewing the files for NEW_DOUBLE.EXE.

To run the program, type:

RUN NEW_DOUBLE [Return]

The program will start and the screen should look similar to that shown in Figure 2.



```
PROGRAM NEW_DOUBLE: VERSION 3 : 4 OCTOBER 89

DOUBLET DISTRIBUTION METHOD IS USED TO DETERMINE
INCOMPRESSIBLE FLOW AROUND AN ELLIPSE , SYMMETRICAL
AIRFOIL OR ARBITRARY-SYMMETRIC SHAPE AT ZERO ANGLE OF ATTACK

PROGRAM ASSUMES A NONDIMENSIONAL CHORD, THAT IS, THE
VALID RANGE OF X IS FROM 0 TO 1.

ENTER TYPE OF BODY SHAPE DESIRED:
    1)  ELLIPTIC
    2)  SYMMETRICAL AIRFOIL-LIKE OR
    3)  ARBITRARY SYMMETRIC SHAPE

ENTER 1, 2, OR 3.

NOTE THAT OPTION 3 WILL REQUIRE MANUALLY INPUTTING DATA
POINTS FOR THE UPPER SIDE OF THE RESPECTIVE BODY
```

Figure 2. Initial Screen for Program NEW_DOUBLE

VI. SAMPLE GRAPHICAL OUTPUTS

A. SAMPLE PROBLEM ONE

For the elliptic case, respond to the initial screen request by entering:

1 (Return)

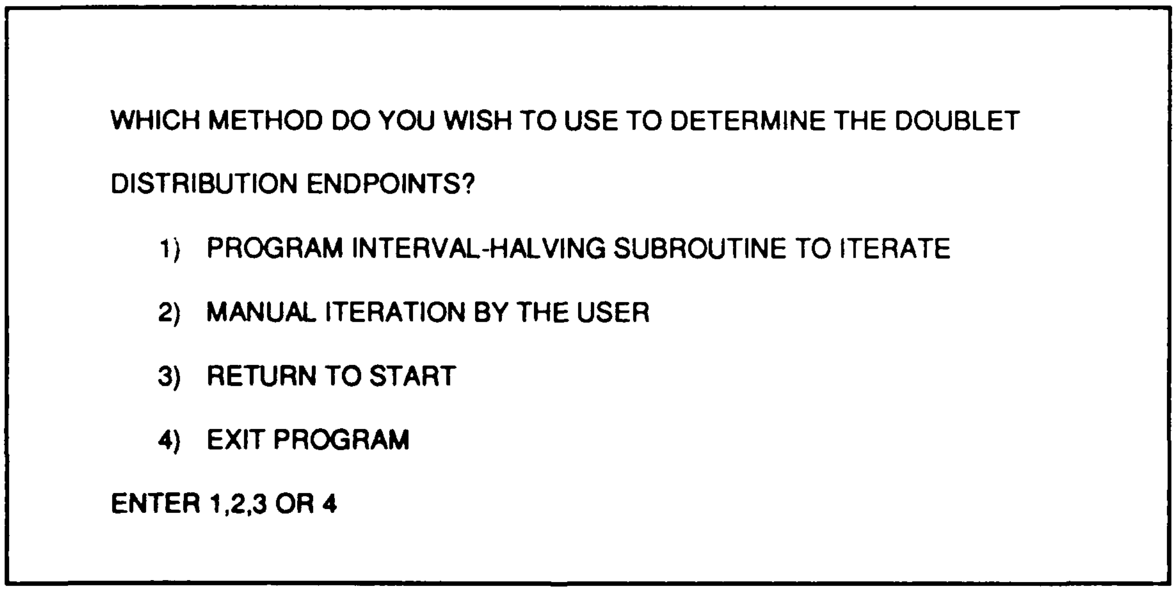
Respond to the request for the thickness ratio by entering:

0.1 (Return)

Now enter the number of intervals you desire the doublet distribution to have by entering:

10 [Return]

The screen should now look like that shown in Figure 3.



```
WHICH METHOD DO YOU WISH TO USE TO DETERMINE THE DOUBLET

DISTRIBUTION ENDPOINTS?

    1)  PROGRAM INTERVAL-HALVING SUBROUTINE TO ITERATE

    2)  MANUAL ITERATION BY THE USER

    3)  RETURN TO START

    4)  EXIT PROGRAM

ENTER 1,2,3 OR 4
```

Figure 3. Endpoint Determination Method Selection Screen

Respond to the question by entering:

1 [Return]

If you should desire to enter your own values, enter **2**.

The next values you will be required to enter are for the X location tolerance and the stagnation point velocity function tolerance. It is recommended that values of 10E-6 (0.000001) be used. The maximum number of iterations should be set at a value of at least 20 when using such small tolerances. Additionally, if you desire to use, for example, 10 intervals, you should use 10E-4 so as to achieve a small velocity magnitude at the stagnation points.

The output parameter entry has only to do with the interval halving subroutine. Unless you are having problems with the program or are interested in the convergence of the solution, it is recommended that this value be set to zero (0).

Following entry of the output parameter, the program begins the solution process. It returns with UO and U1, the values for the X velocity component at the leading and trailing stagnation points respectively and the values for XS and XF, the beginning and ending points of the line doublet distribution. If the values for UO and U1 are sufficiently close to zero, say less than 10E-3 (0.001), then enter:

Y [Return]

If you desire more accuracy, enter:

N [Return]

and then reenter the tolerance and maximum iteration values. Responding with a **(Y)** will cause the program to proceed to the output stage. Values will be printed to the screen and to the following data files:

DUBLET.DAT	:	DOUBLET STRENGTH DISTRIBUTION
SHAPE.DAT	:	BODY SURFACE COORDINATES
PRESSURE.DAT	:	SURFACE PRESSURE DISTRIBUTION

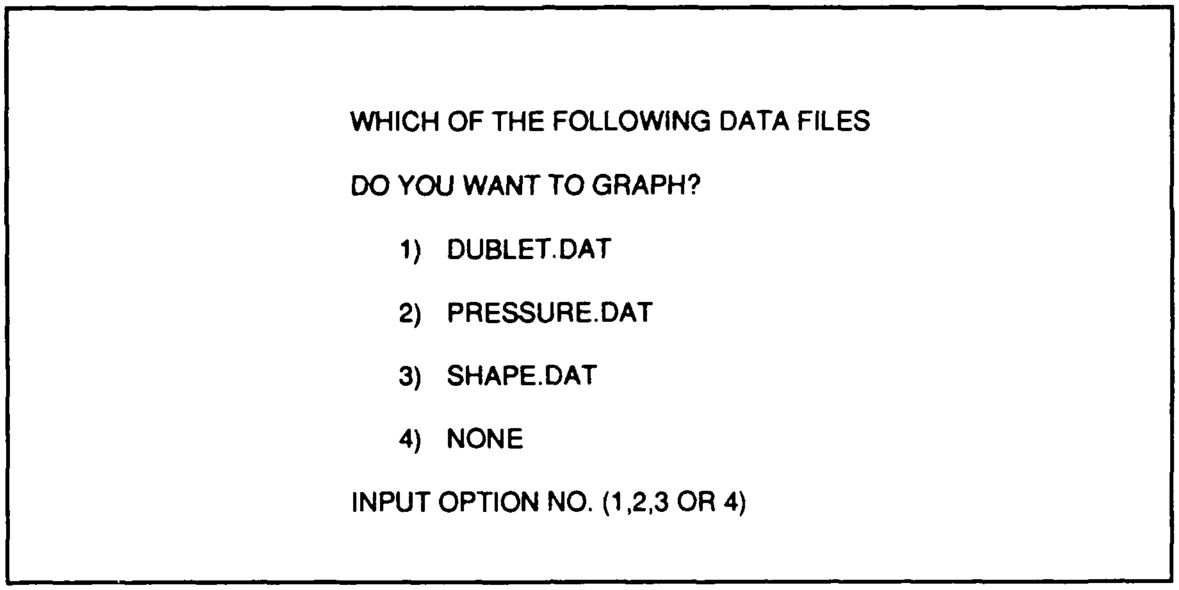
You will be asked for the number of pressure coefficient output points you desire. This number is independent of the number of intervals of the line doublet distribution. It affects only the number of output data points and not the accuracy of the solution. After entering the number of Cp output points, pressure distribution data will be displayed to your screen. The program now asks if you want to print the results **(Y/N)**. Enter your response and select the respective file which you want to print from a tabulated listing. However, be aware that you must have already logged onto the KELLY terminal to print anything, or be at a terminal which is connected to a printer.

You will now be asked if you want to graph the results **(Y/N)**. If you respond affirmatively, the screen will look similar to Figure 4.

Once you have selected your plotting option and the respective plot has appeared on your screen (on the KELLY terminal screen if you are printing items) you will be asked if you would like a print of the plot **(Y/N)**. Answer accordingly and continue with the program.

You will now be asked if you would like to make another run. Enter:

1 [Return]



```
WHICH OF THE FOLLOWING DATA FILES

DO YOU WANT TO GRAPH?

    1)  DUBLET.DAT

    2)  PRESSURE.DAT

    3)  SHAPE.DAT

    4)  NONE

INPUT OPTION NO. (1,2,3 OR 4)
```

Figure 4. Plotting Options Screen

B. SAMPLE PROBLEM TWO

Sample problem two will work through the airfoil-like shape case and the user will supply the values of XS and XF. The user may experiment with manual iteration, however to save space this sample will use previously determined satisfactory values of XS and XF for the initial guess.

You should now be back at the initial screen and it should look like Figure 2. For the airfoil-like case enter:

2 [Return]

Respond to the request for the thickness ratio by entering:

.12 [Return]

For the chordwise location of maximum thickness, enter:

.30 [Return]

Now enter the number of intervals you desire the doublet distribution to have by entering:

10 [Return]

The next step is to select the method for the determination of the endpoints for the doublet distribution. The screen should look like Figure 3. This time respond to the question by entering:

2 [Return]

For the doublet distribution starting point, XS, enter

.0082129128 [Return]

For the doublet distribution ending point, XF, enter

.9994138 [Return]

As with the previous example, the program now begins the solution process. It returns with U0 and U1, the values for the X velocity component at the stagnation points. It also echoes back the values entered for XS and XF. If the returned values for U0 and U1 are sufficiently close to zero, then enter:

Y [Return]

This response will cause the program to proceed to the output stage. Values will be printed to the screen and to the data files.

Enter the number of pressure coefficient output points you desire. You are reminded that this number is independent of the number of intervals of the line doublet distribution and it does not affect the accuracy of the solution.

Again, you will be afforded the opportunity to print and graph the results as in sample problems one.

The program now asks if you want to make another run. Enter:

1 [Return]

C. SAMPLE PROBLEM THREE

Sample Problem Three provides an example of arbitrary shape analysis. You should now be back at the initial screen and it should look like Figure 2. For the symmetric shape case enter:

3 [Return]

Once you have entered this response, your screen should look similar to Figure 5.

```
HOW MANY UPPER PROFILE DATA POINTS DO
YOU DESIRE? (ENTER A NUMBER BETWEEN 3 AND 100)


BE AWARE THAT THE LEADING EDGE OF YOUR DESIRED
SHAPE HAS BEEN PROGRAMMED TO BE AT THE ORIGIN
AND THAT YOUR TRAILING EDGE IS AT (1,0). SCALE
YOUR SHAPE/OBJECT ACCORDINGLY.
```

Figure 5. Symmetric Shape Data Point Input Screen

Enter the number of points you wish to use to describe your symmetric shape. You will then be given the opportunity to enter each point. Once you have entered all of your surface points, the program will ask if you want to check your input data. You may then make any corrections as necessary. When you have finished correcting your data, enter **N** to the question asking you if you have any 'input data corrections.' The program will then proceed as described in example problems one and two.

This completes the sample problems for the NEW_DOUBLE program. Representative graphical outputs created by these sample runs are listed in Figures 6 through 8. Since the bodies analyzed by this program are symmetrical with respect to the x axis, only the upper surface body shape coordinates and pressure coefficients are output. For this reason, the piecewise constant doublet strength M(I) is divided by two to indicate the portion affecting the upper surface.

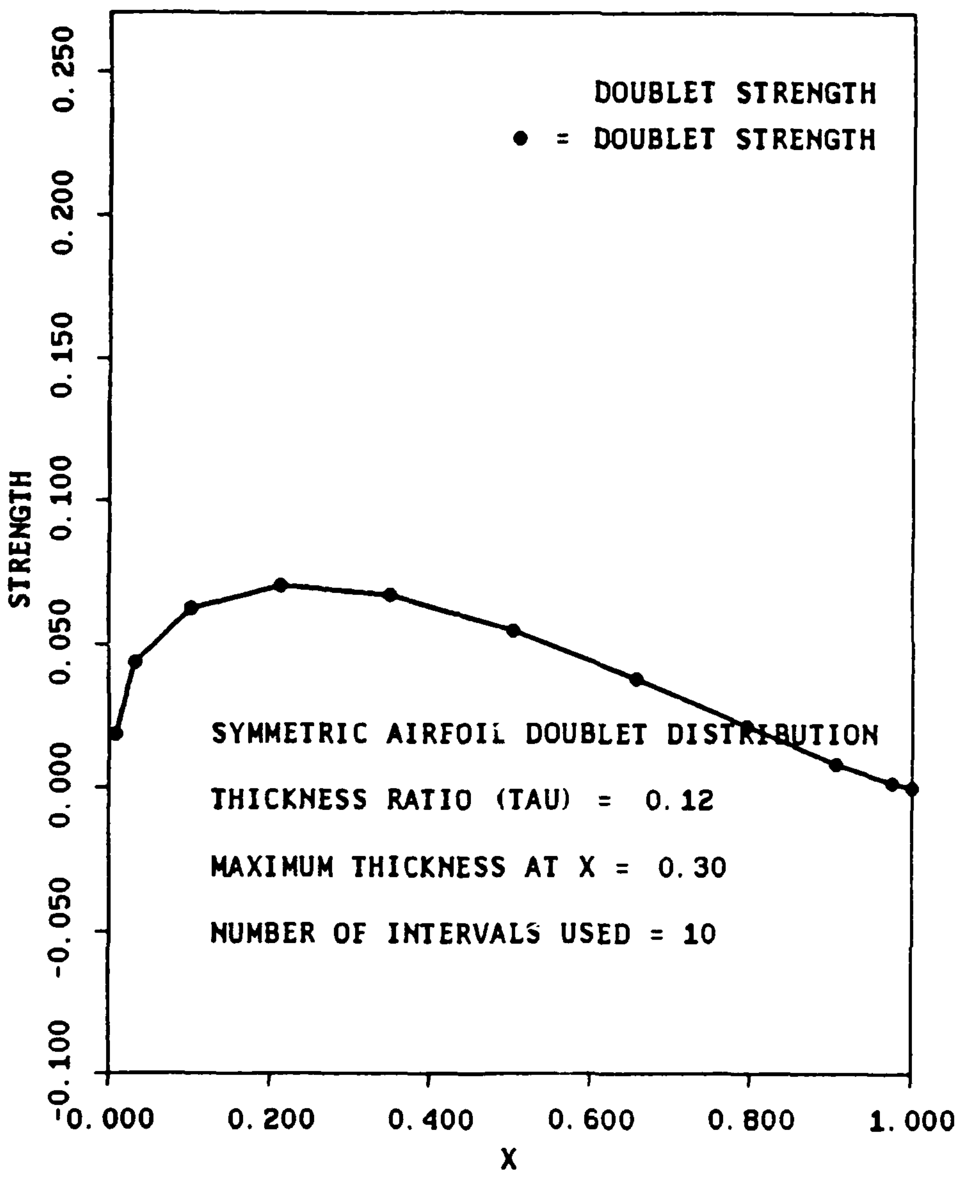


Figure 6. Doublet Strength Distribution

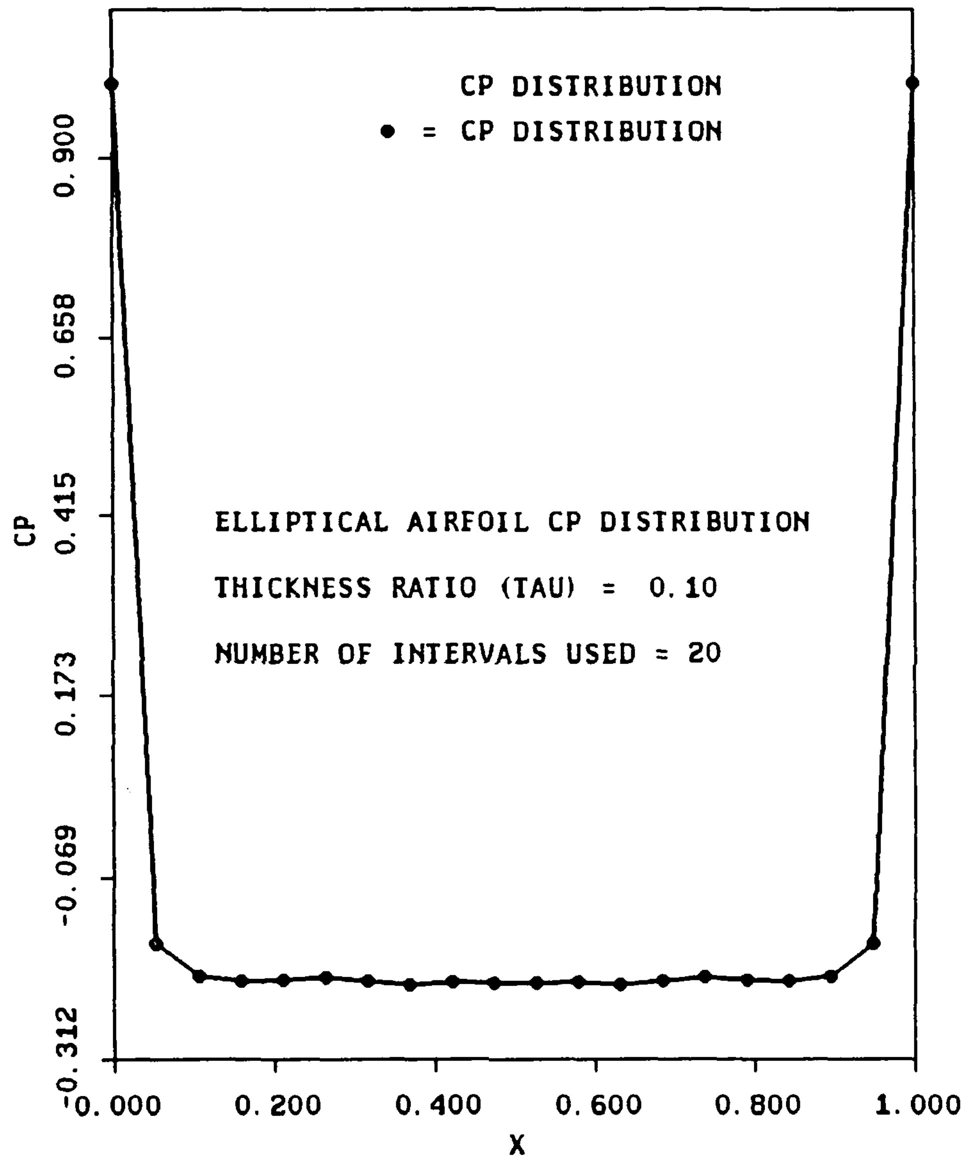


Figure 7. Cp Distribution

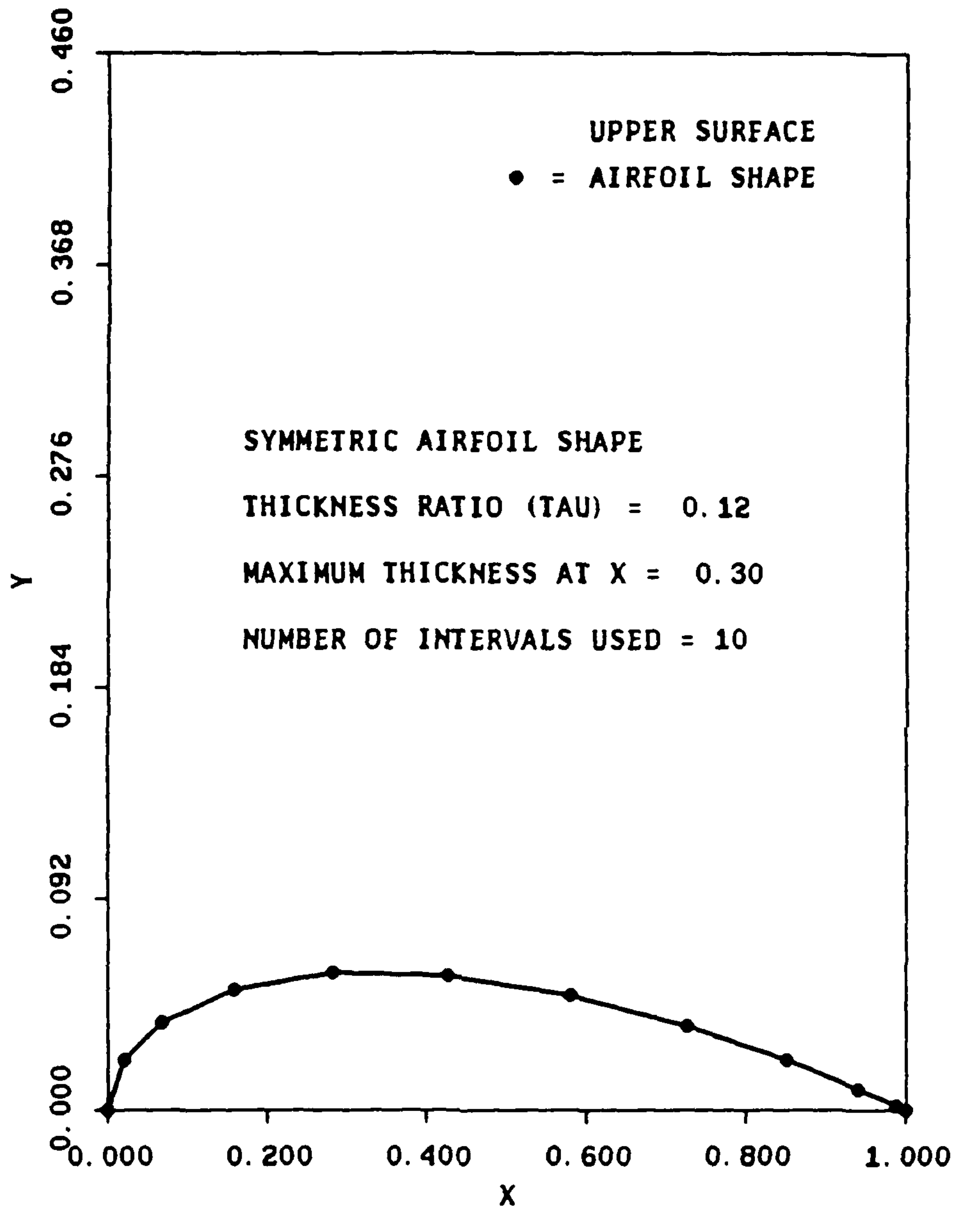


Figure 8. Airfoil Shape

APPENDIX B

PROGRAM NEW_PANEL USER'S MANUAL

USER'S GUIDE CONTENTS

I. INTRODUCTION

The purpose of the NEW_PANEL program is to provide an analysis of the aerodynamics of NACA four-digit airfoils and airfoils of the NACA 230XX family using the panel method. This program has been modified to accept arbitrary airfoil surface coordinate input. NEW_PANEL has also been adapted to analyze viscous effects.

II. ASSUMPTIONS AND LIMITATIONS

This program is limited to single-element airfoils. The solution is determined for conditions of incompressible and inviscid irrotational flow. The coefficient of drag provided in the results is due to numerical round-off error. When considering the viscous analysis loop of the program, it is important that you understand that the Cebeci eddy-viscosity program adaptation is sensitive to flow separation on the airfoil. Boundary layer thickness and other boundary layer characteristics will be computed. It is advised that viscous analysis be limited to small angles of attack and to relatively slender airfoils.

III. INPUT DESCRIPTION

As with the NEW_DOUBLE program, there are very few input values required for this simple program. Their description and program variable names are listed below.

NUPPER	Number of nodes on the upper surface.
NLOWER	Number of nodes on the lower surface.
X(1),Y(1)	Surface coordinates.

These may be entered from the keyboard, from a data file, or from data statements. The program is capable of generating an approximation for airfoils of the NACA XXXX and 230XX series.

ALPHA —Angle of attack. (Angle between the chord and the freestream velocity.)

RL—Chord Reynold's Number

XCTRI(1) - Flow transition point from laminar to turbulent flow on the top of the airfoil

XCTRI(2) - Flow transition point from laminar to turbulent flow on the bottom of the airfoil.

IV. INPUT RESTRICTIONS

The program, as written, is limited to 100 total surface nodes. This may be modified by changing the size of the arrays; however, only a very complex surface should require that many values to accurately define the surface. If that is the case, a more sophisticated program should be considered for the investigation. As mentioned above, the computer generated approximations to airfoil shapes are limited to the NACA XXXX and 230 XX series. The program will accept values for ALPHA up to 90 degrees, but the user is cautioned that since separation can exist for angles of attack as low as 5°–10°, results for values above about 10° may be suspect.

V. OUTPUT VARIABLES FOR VISCOUS RESULTS

XC - Airfoil Coordinate (Abscissa)

S - Station Location

VW - Wall Shear

CF - Coefficient of Friction

DLS - Displacement Thickness

THT - Momentum Thickness

VI. SAMPLE PROBLEMS

A few sample problems will illustrate the use of the NEW_PANEL program. The first run will be done using an approximation to a NACA 0012 airfoil which is generated by the program using the information associated with each digit in the NACA number. The second run will analyze a NASA LS(1)-0013 airfoil using a set of data statements containing the airfoil surface coordinates. These statements have been inserted into the proper location in the program already. The last sample problem will re-analyze the LS(1)-0013 airfoil but now viscous effects will be included.

VII. STARTING THE PROGRAM

Begin with the screen showing the DCL prompt, which looks like this:

```
$
```

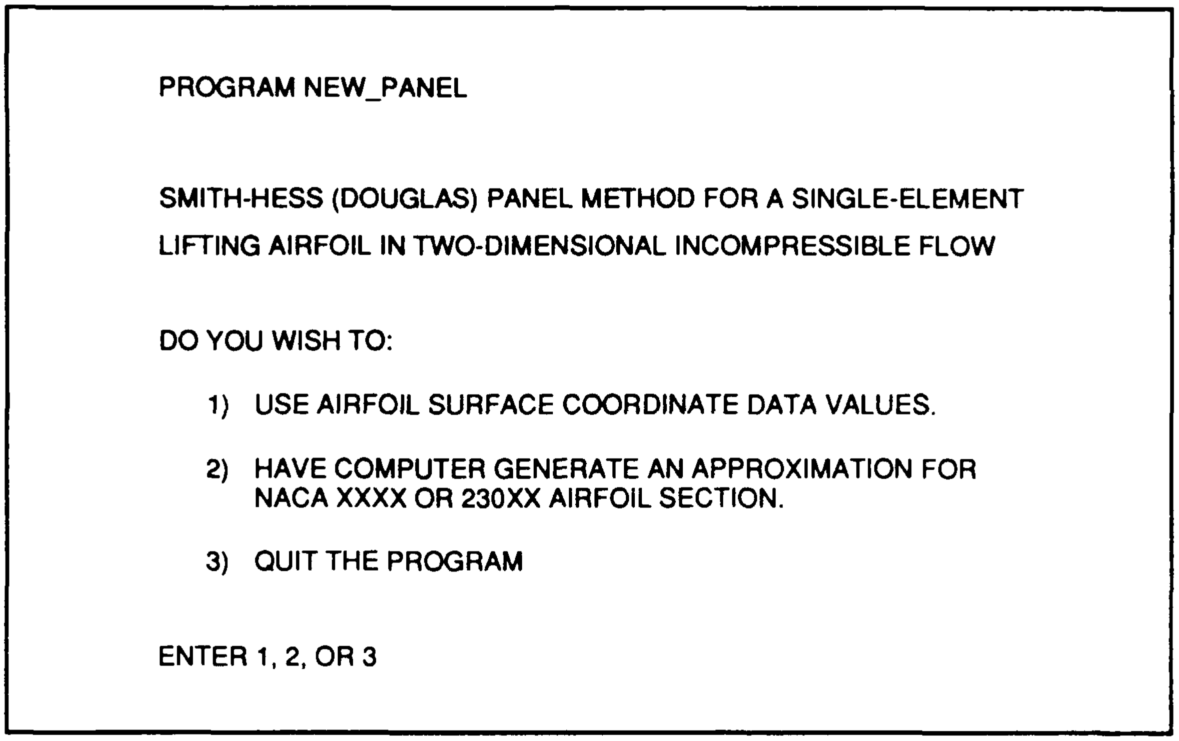
Next, ensure that the program is in your directory by typing:

```
DIR [Return]
```

and viewing the files for NEW_PANEL.EXE. To run the program, type:

```
RUN NEW_PANEL [Return]
```

The program will start and the screen should look similar to what is shown in Figure 9.



```
PROGRAM NEW_PANEL

SMITH-HESS (DOUGLAS) PANEL METHOD FOR A SINGLE-ELEMENT
LIFTING AIRFOIL IN TWO-DIMENSIONAL INCOMPRESSIBLE FLOW

DO YOU WISH TO:

    1)  USE AIRFOIL SURFACE COORDINATE DATA VALUES.

    2)  HAVE COMPUTER GENERATE AN APPROXIMATION FOR
        NACA XXXX OR 230XX AIRFOIL SECTION.

    3)  QUIT THE PROGRAM

ENTER 1, 2, OR 3
```

Figure 9. Initial Screen for Program NEW_PANEL

VIII. SAMPLE GRAPHICAL OUTPUTS

A. SAMPLE PROBLEM ONE

For the first case we will have the computer generate an approximation for the shape of a NACA 0012 airfoil, consisting of 20 surface panels, using an algorithm contained in subroutine NACA45. The angle of attack of the onset flow will be six degrees. To use the approximation method, enter:

2 [Return]

Respond to the request for the number of surface data points by entering:

20 [Return]

Confirm the number of surface data points you desire by entering:

1 [Return]

Although the program will allow a different number of upper and lower surface data points, it is recommended that you try and keep them equal. An unequal number of nodes yields trailing-edge panels of unequal length, which lowers the accuracy of the approximation of the Kutta condition. Respond to this question by entering:

1 [Return]

The next question asks for the NACA number of the airfoil you are considering. For this case we will look at the NACA 0012, so enter:

0012 [Return]

The screen should now look like similar to Figure 10.

The program is now ready to perform its calculations. The final piece of information required is the angle of attack, ALPHA. For this case, respond to the question by entering:

6 [Return]

Following entry of the angle of attack, the program begins the solution process. Values scroll up the screen and are simultaneously being written to the data files. You should now see a screen similar to the one shown in Figure 11.

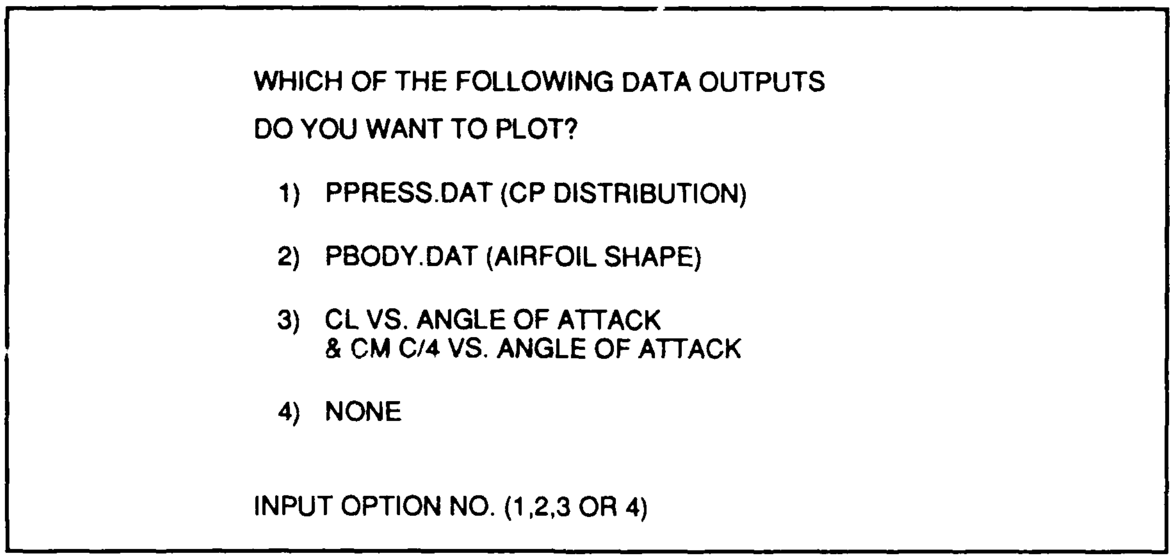
Should you select to print the results, you will be given the option to print both of the data files or just the one you want. Once you have finished printing the results, you will be asked if you want to graph the results. Respond affirmatively and the screen should then look similar to Figure 12.

```
ENTER NUMBER OF SURFACE DATA POINTS DESIRED

20

NUMBER OF SURFACE DATA POINTS TO BE GERATED = 20
IS THIS VALUE CORRECT? (YES=1, NO=2)

1

ARE THE NUMBER OF UPPER AND LOWER SURFACE
DATA POINTS (NODES) EQUAL? (YES=1, (NO=2)

1

INPUT NACA NUMBER, ANY FOUR DIGIT OR 230XX SERIES

0012

INPUT ALPHA IN DEGREES
```

Figure 10. Screen Showing Data for Computer Generated Airfoil

```
PROGRAM NEW_PANEL RESULTS HAVE BEEN WRITTEN TO FILES:
PBODY.DAT : BODY SURFACE COORDINATES
PPRESS.DAT : SURFACE PRESSURE DISTRIBUTION
WOULD YOU LIKE TO PRINT THE RESULTS (Y/N)?
```

Figure 11. Printing Option Screen



```
WHICH OF THE FOLLOWING DATA OUTPUTS
DO YOU WANT TO PLOT?

  1)  PPRESS.DAT (CP DISTRIBUTION)

  2)  PBODY.DAT (AIRFOIL SHAPE)

  3)  CL VS. ANGLE OF ATTACK
      & CM C/4 VS. ANGLE OF ATTACK

  4)  NONE

INPUT OPTION NO. (1,2,3 OR 4)
```

Figure 12. Graphical Selection Screen

Once the selected plot is displayed on your screen (screen KELLY if you are printing) you will be given the option of printing the plot. Again, you must have already used the "set host kelly" command to print items. If you elect not to print the graphical output you screen will again look similar to Figure 12. Selecting option 4 (**NONE**) will exit you from the graphing loop. You will now be asked to analyze the viscous effects for the airfoil. Respond negatively by entering:

N [Return]

A new screen will be presented and the program now asks if you want to make another run. Enter:

1 [Return]

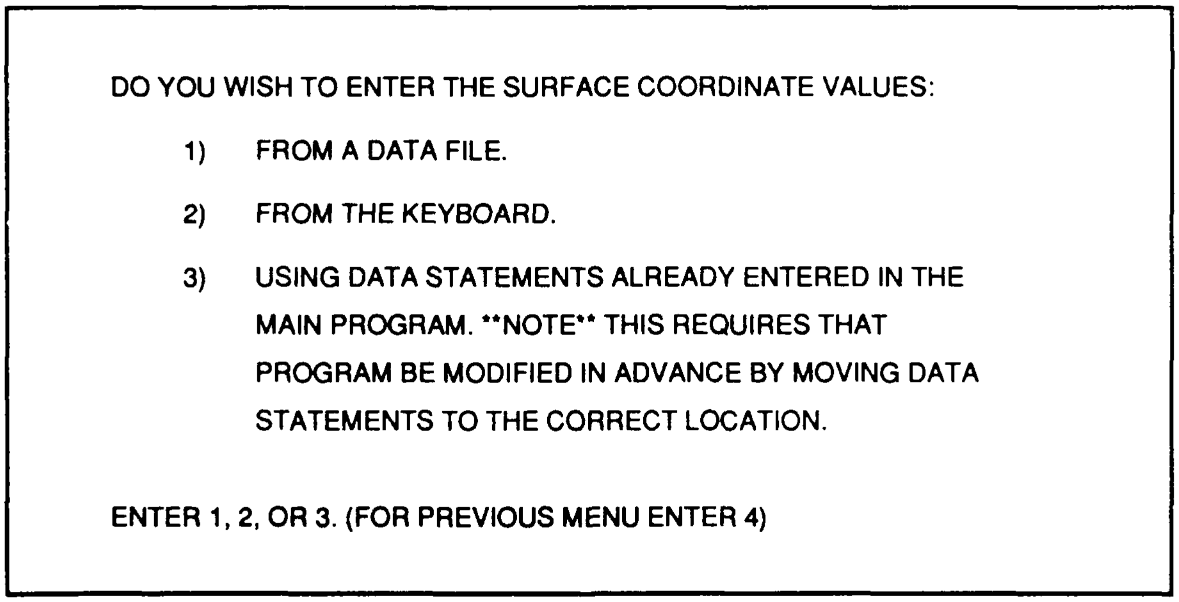
B. SAMPLE PROBLEM TWO

This time the sample problem will examine a NASA LS (1)-0013 whose coordinates have been entered as data statements in the program. You should now be back at the initial screen and it should look like Figure 9. Since you will be using actual airfoil coordinate data values, enter:

1 [Return]

The screen shown in Figure 13 now presents you with the three choices available for entering the airfoil surface coordinate data values. You will be using the data statements, so enter:

3 [Return]



```
DO YOU WISH TO ENTER THE SURFACE COORDINATE VALUES:

     1)   FROM A DATA FILE.

     2)   FROM THE KEYBOARD.

     3)   USING DATA STATEMENTS ALREADY ENTERED IN THE
          MAIN PROGRAM. **NOTE** THIS REQUIRES THAT
          PROGRAM BE MODIFIED IN ADVANCE BY MOVING DATA
          STATEMENTS TO THE CORRECT LOCATION.

ENTER 1, 2, OR 3. (FOR PREVIOUS MENU ENTER 4)
```

Figure 13. Menu for Surface Coordinate Data Entry Method

The number of data points has been entered via the data statements, therefore you are not asked that question for this case. For the angle of attack, again enter:

6 [Return]

As you saw in the previous example, values scroll up the screen. The program will again allow you to print or graph the respective results as before. Additionally, you will again be asked if you want to analyze viscous effects. Respond accordingly to exercise the required program options. Finally, the program will ask if you want to make another run. Enter:

1 [Return]

C. SAMPLE PROBLEM THREE

As noted earlier, this sample problem will again analyze the LS(1)-0013 airfoil but with viscous effects. You should now be back at the initial screen and it should look like Figure 9. Since you will be using airfoil surface coordinate data values enter:

1 [Return]

The screen should again look like Figure 13. Again enter the response **3** in that data statements will again be used.

3 [Return]

For the angle of attack response enter:

0 [Return]

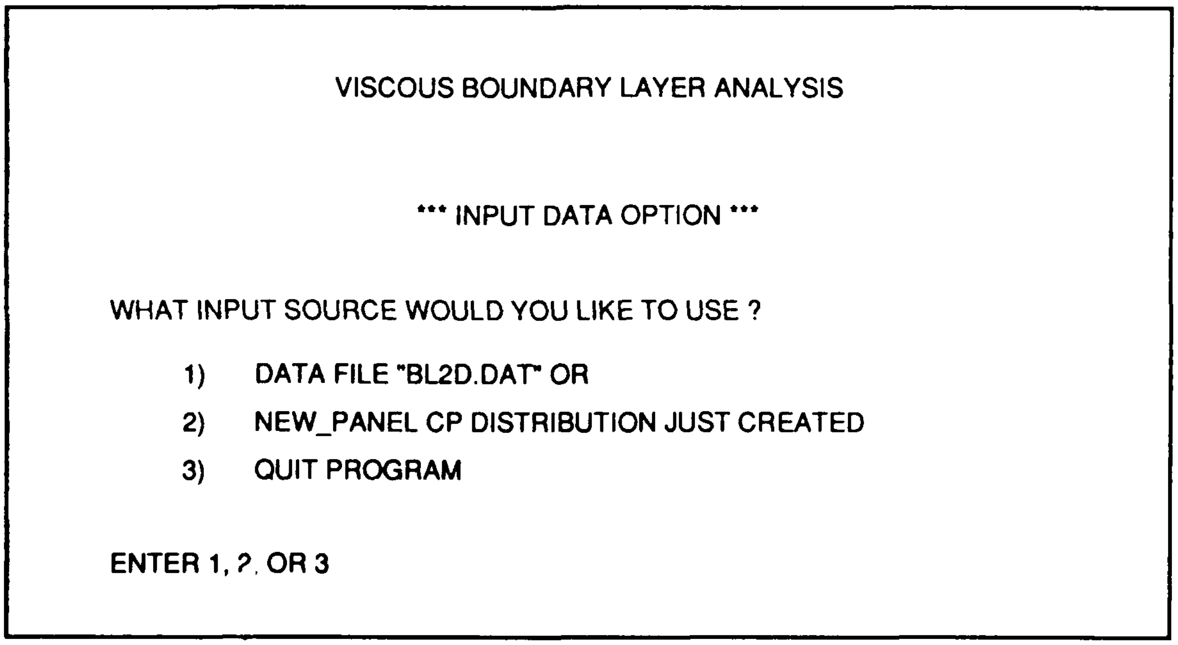
As you have seen in the two previous examples, values scroll up the screen. The program will again allow you to print and/or graph the respective results as before. When asked if you would like to analyze the viscous effects for this airfoil enter:

Y [Return]

The screen should now look similar to Figure 14.

The first option (1) is used to input an arbitrary external velocity profile. The external velocity values at each respective point were obtained from the expression: SQRT(1-Cp). To input the Cp distribution just created for the LS(1)-0013 airfoil enter:

2 [Return]



```
                 VISCOUS BOUNDARY LAYER ANALYSIS


                      *** INPUT DATA OPTION ***

WHAT INPUT SOURCE WOULD YOU LIKE TO USE ?

        1)    DATA FILE "BL2D.DAT" OR
        2)    NEW_PANEL CP DISTRIBUTION JUST CREATED
        3)    QUIT PROGRAM

ENTER 1, 2, OR 3
```

Figure 14. Menu for Viscous Data Input Option

You will now be asked to enter the flow Reynold's Number. Enter:

6000000 [Return]

Now you will be asked to enter the respective nondimensionalized values of XCRIT(1) and XCRIT(2). Again these values correspond to the point along the chord of the airfoil at which flow transition from laminar to turbulent occurs for the top and bottom of the airfoil, respectively. Enter **.3** for both values. To avoid flow separation, these value should be greater than 0.15 for analysis at angles of attack in excess of approximately 5°.

The program will now begin to process the input data and determine the boundary layer characteristics. Upon completion of the computations the screen should look similar to Figure 15.

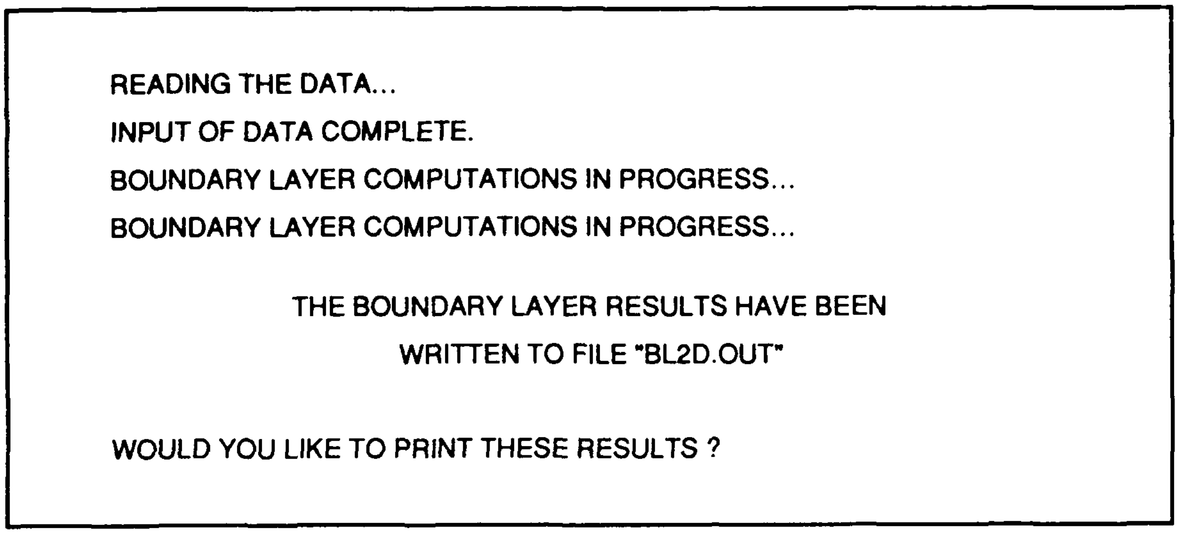
Remember that in order to print the results you must be logged onto a computer terminal which is connected to a printer. Enter the following command to print the boundary layer results:

Y [Return]

Once you have finished the viscous flow analysis process, the program will again ask you if would like to make another run of NEW_PANEL. Enter the following command to exit the NEW_PANEL program:

2 [Return]

This completes the sample problems for the NEW_PANEL program. Representative graphical outputs created by these sample runs are shown in Figures 16 through 18.



```
READING THE DATA...
INPUT OF DATA COMPLETE.
BOUNDARY LAYER COMPUTATIONS IN PROGRESS...
BOUNDARY LAYER COMPUTATIONS IN PROGRESS...

                    THE BOUNDARY LAYER RESULTS HAVE BEEN
                         WRITTEN TO FILE "BL2D.OUT"

WOULD YOU LIKE TO PRINT THESE RESULTS ?
```

Figure 15. Viscous Data Output File Option Screen

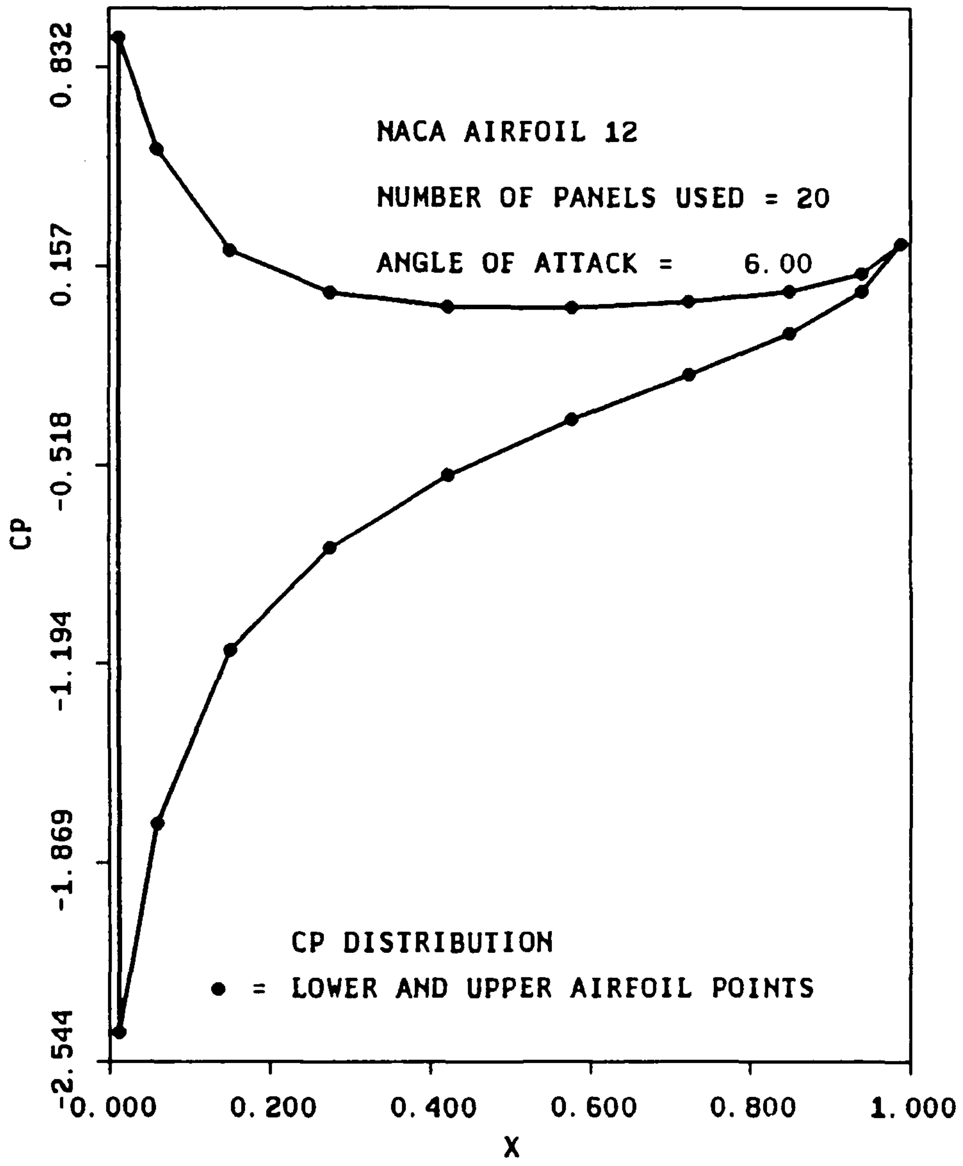


Figure 16. Cp Distribution

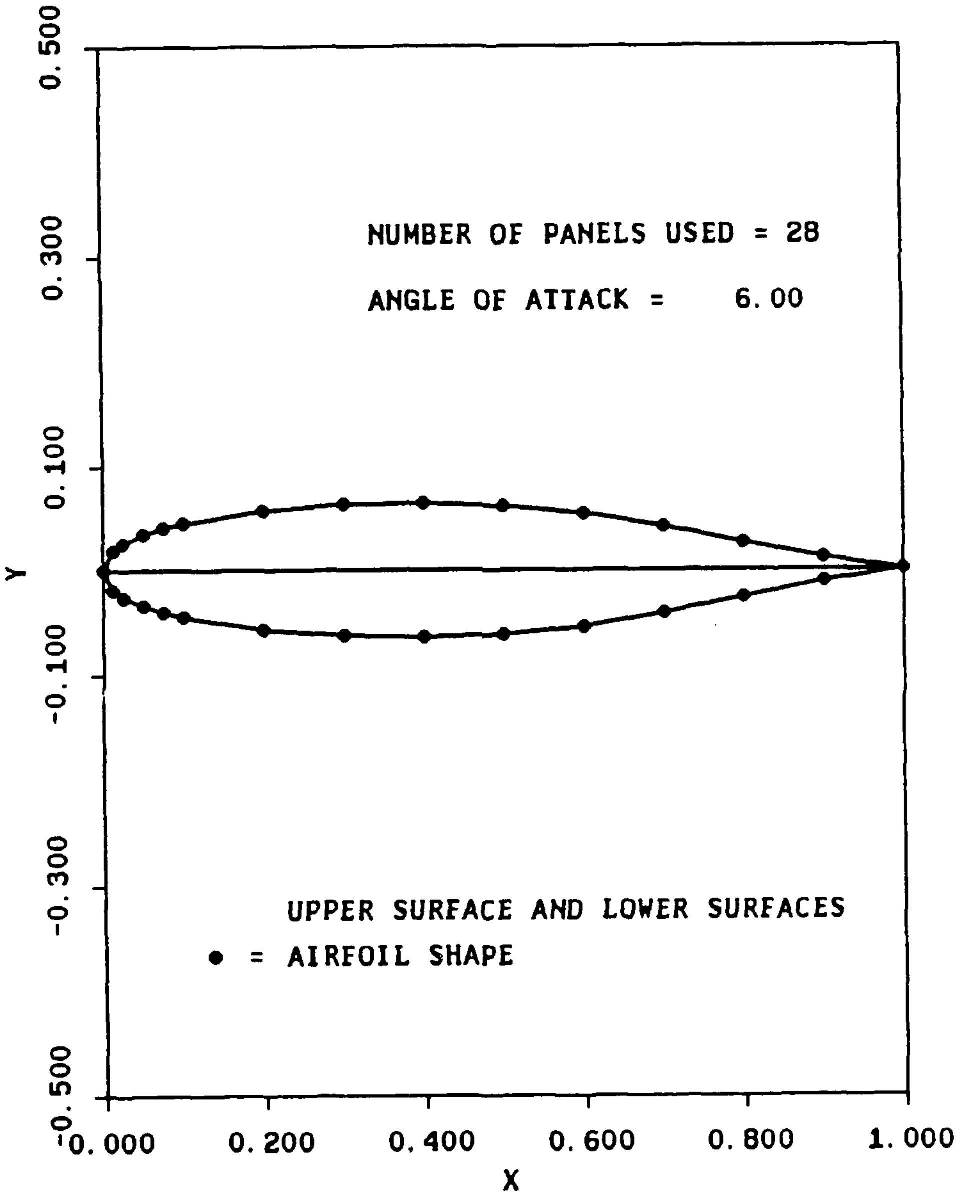


Figure 17. Body Shape

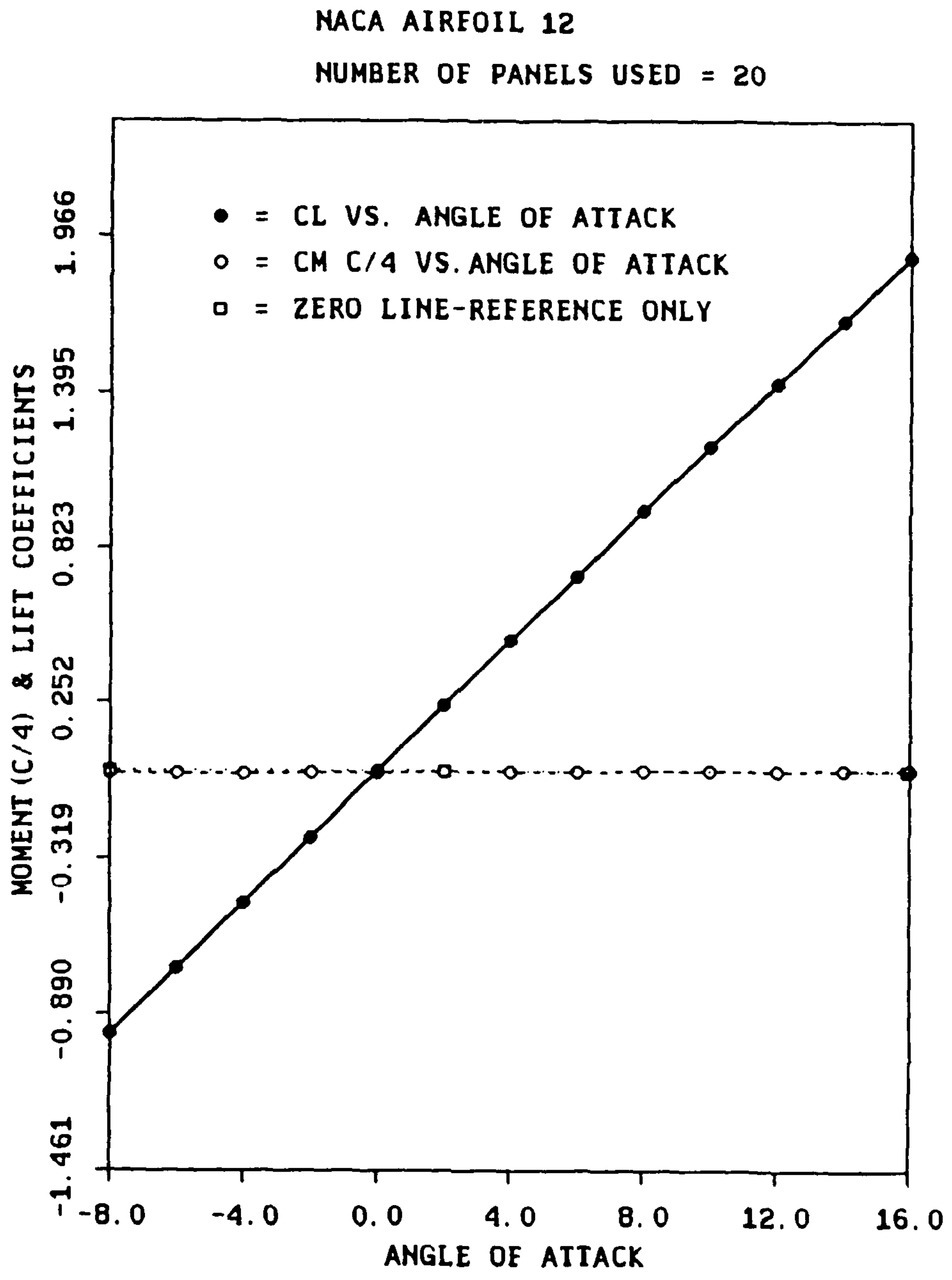


Figure 18. Cl & Cm c/4 vs. Alpha

APPENDIX C
PROGRAM NEW_VOR USER'S MANUAL

USER'S GUIDE CONTENTS

I. INTRODUCTION

The purpose of the NEW_VOR program is to provide an application of the vortex lattice method for the determination of the lift distribution of a flat rectangular plate. This method is based on a distribution of discrete horseshoe vortices over a wing surface that has been divided into a finite number of panels. A system of linear equations is developed for the vortex strengths on the panels and solved by matrix methods.

II. ASSUMPTIONS AND LIMITATIONS

This program is limited to flat rectangular wings which it divides into panels, using a uniform grid. Additionally, the uniform grid spacing method incorporates an enhancement whereby the panels do not extend to the wing tips, but only to a distance of d/4 from the tips. The value of d is the spanwise width of a wing panel.

The solution is determined for conditions of incompressible and inviscid irrotational flow. Since we are considering an inviscid fluid, the coefficient of drag provided in the results is an accumulation of numerical errors. This program is intended to be used for the analysis of flat rectangular wings with low aspect ratio.

III. INPUT DESCRIPTION

There are very few input values required for this simple program. Their description and program variable names are listed below.

AR—Aspect ratio of the wing. (Span) ^{2}/Area or Span/Chord.

NX,NY—Number of vortices in the X and Y directions.

ALPHA—Angle of attack. (Angle between the chord and the freestream velocity.)

IV. INPUT RESTRICTIONS

The program, as written, is limited to 350 total surface vortices. This may be modified by changing the size of the arrays, however for the wings that this program was intended to analyze, this should be sufficient. The program will accept values for ALPHA up to 45 degrees, but, as noted previously with program NEW_PANEL, the user is cautioned that values above about 10° may result in output data which in incorrect.

V. SAMPLE PROBLEMS

Two sample problems will be used to illustrate the use of the NEW_VOR program. The first run will use a flat rectangular wing with an aspect ratio of two. The lattice will be created by placing three vortices on the wing in the X direction and five vortices on the wing in the Y direction. The vortices will be distributed using the *Uniform Grid spacing method* and the wing will be set at an angle of attack (alpha) of six degrees. The second run will use the same wing, but with five vortices on the wing in the X direction and 10 vortices on the wing in the Y direction.

VI. STARTING THE PROGRAM

Begin with the screen showing the DCL prompt, which looks like this:

```
$
```

Next, ensure that the program is in your directory by typing:

```
DIR [Return]
```

and viewing the files for NEW_VOR.EXE.

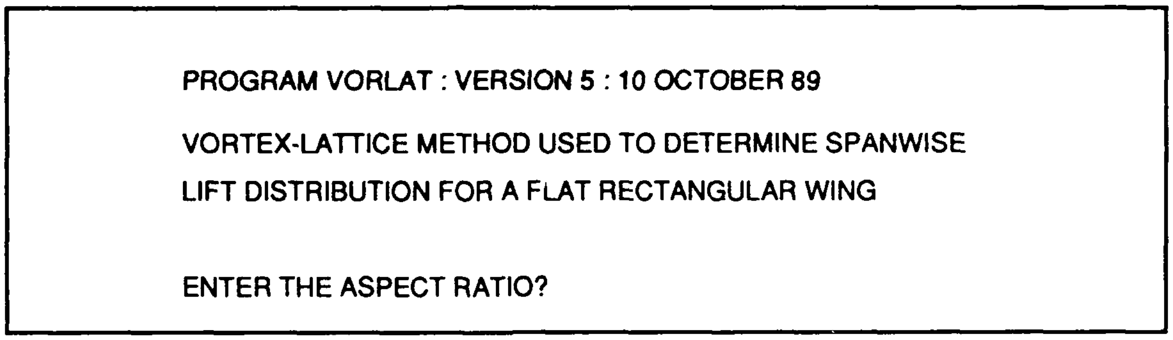
To run the program, type:

```
RUN NEW_VOR [Return]
```

VII. SAMPLE GRAPHICAL OUTPUTS

A. SAMPLE PROBLEM ONE

The program will start and the screen should look similar to what is shown in Figure 19.



```
PROGRAM VORLAT : VERSION 5 : 10 OCTOBER 89

VORTEX-LATTICE METHOD USED TO DETERMINE SPANWISE
LIFT DISTRIBUTION FOR A FLAT RECTANGULAR WING


ENTER THE ASPECT RATIO?
```

Figure 19. Initial Screen for Program NEW_VOR

Respond to the request for the aspect ratio by entering:

2 [Return]

Respond to the request for the number of vortices by entering:

3,5 [Return]

Finally, enter the angle of attack in degrees:

6 [Return]

The screen is then cleared and you will be presented with what is shown in Figure 20. If your display agrees with this, respond to the question by entering:

1 [Return]

```
THE CURRENT VALUES ARE:

    1)   ASPECT RATIO . . . . . . . . . . . . . . . . . . . = 2.000000
    2)   NUMBER OF VORTICES (NX,NY) = 3, 5
    3)   ANGLE OF ATTACK (DEGREES) = 6.000000

THE CALCULATED PARAMETERS ARE:

    DELTA X = 0.3333333
    DELTA Y = 0.1904762

NUMBER OF EQUATIONS TO SOLVE = 15
ARE THESE VALUES CORRECT? (YES=1, NO=2)
```

Figure 20. Data Review/Correction Screen

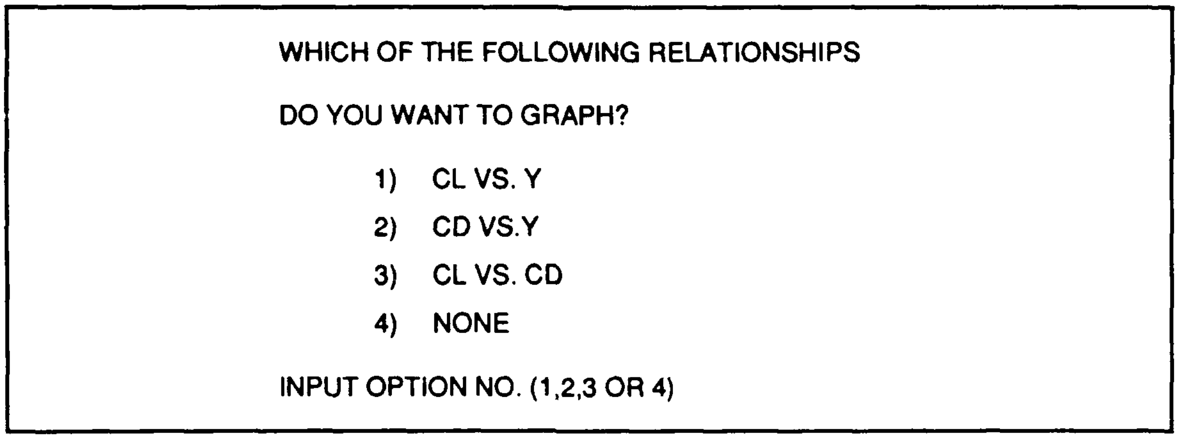
If you should desire to change any values, enter **2**, and you will be asked which value you want to correct and the new desired value. Following entry of the correct values and a positive response, the program begins the solution process. It returns with the coefficients of lift and drag at the indicated spanwise positions, as well as the chordwise center of pressure for those positions. Overall values for the coefficients of lift, drag, induced drag and moment about the leading edge are calculated and then printed out near the bottom of the screen. Don't worry if you miss some of the values as they scroll up on the screen. All the values are printed to both the screen and to the data file (VORLAT4.DAT).

The program now asks if you want to print the results. Entering an affirmative response of 'Y' will print the output file VORLAT4.DAT.

The program will now ask if you want to graph the results. Enter:

Y [Return]

Your screen should now look similar to Figure 21.



```
WHICH OF THE FOLLOWING RELATIONSHIPS

DO YOU WANT TO GRAPH?

        1)  CL VS. Y
        2)  CD VS.Y
        3)  CL VS. CD
        4)  NONE

INPUT OPTION NO. (1,2,3 OR 4)
```

Figure 21. Graphical Selection Screen

Enter a desired plot selection and compare your one plot to the sample output plot at the end of this section. There should not be any difference. You will also be asked if you would like a print of the respective plot. Upon entering:

N [Return]

your screen should once again be similar to Figure 21. Enter a response of **4** to exit the graphing loop.

B. SAMPLE PROBLEM TWO

The program now asks if you want to make another run. Enter:

1 [Return]

You should now be back at the data review/correction screen and it should look like Figure 20.

Now run the same wing, but change the number of vortices to 5 and 10. Enter:

2 [Return]

You want to change the number of vortices, so enter

2 [Return]

Respond to the request for the number of vortices by entering:

5,10 [Return]

The screen is automatically updated and you will see that the number of vortices has changed. As in the previous example, responding with a '1' causes the program to proceed to the output stage. The solution will be printed to the screen and appended to the data file which contains the data from the prior run. Again you will be afforded the opportunity to print and graph the results as in Sample Problem One. Respond accordingly...the output file/graphical plots for all plotting selections are enclosed at the end of this section.

The program now asks if you want to make another run. The session is finished, so enter

2 [Return]

This completes the sample problems for the NEW_VOR program. Figures 22 through 24 give representative graphical outputs created by these sample problems. To create these plots, five vortices across the wing chord (NX) and 10 vortices across the span (NY) were used.

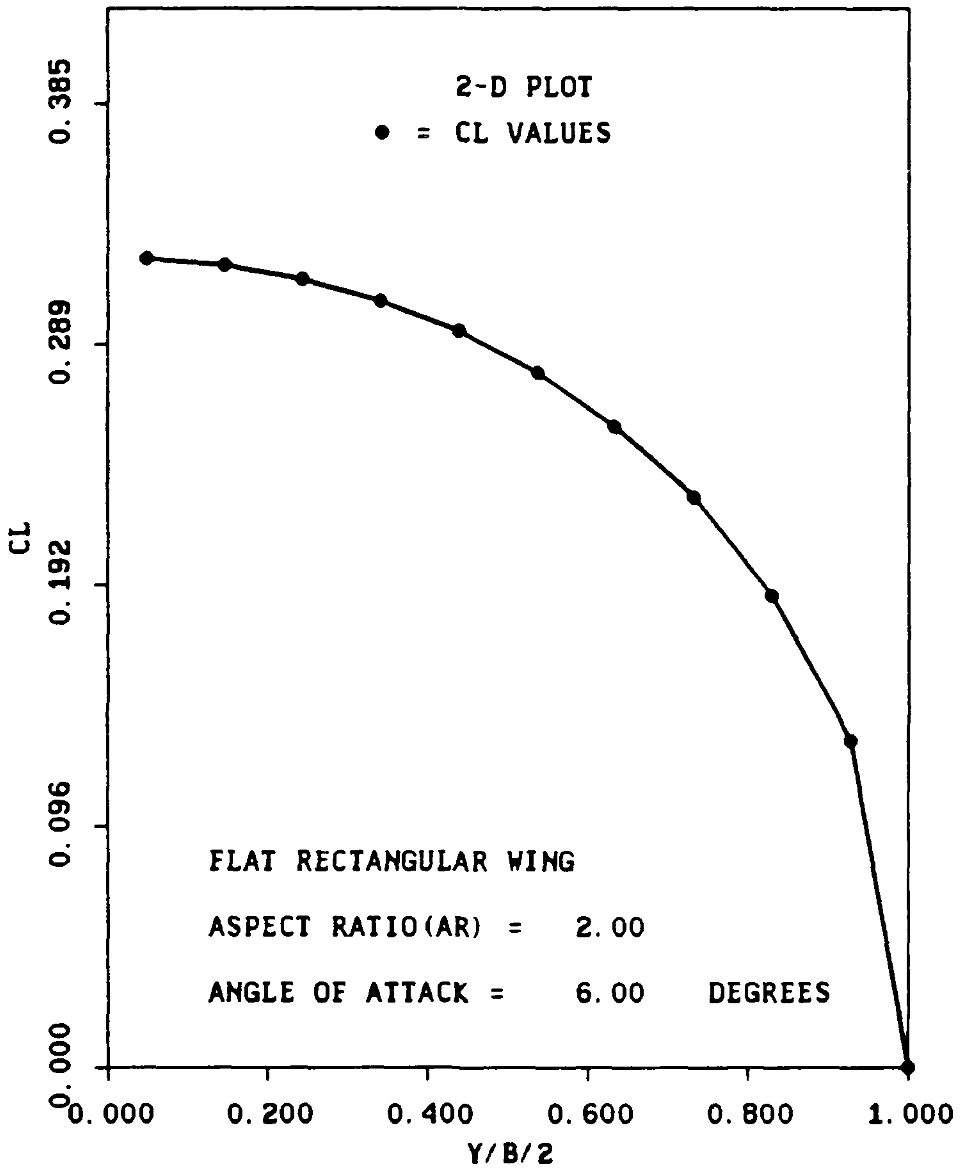


Figure 22. Cl vs. Y

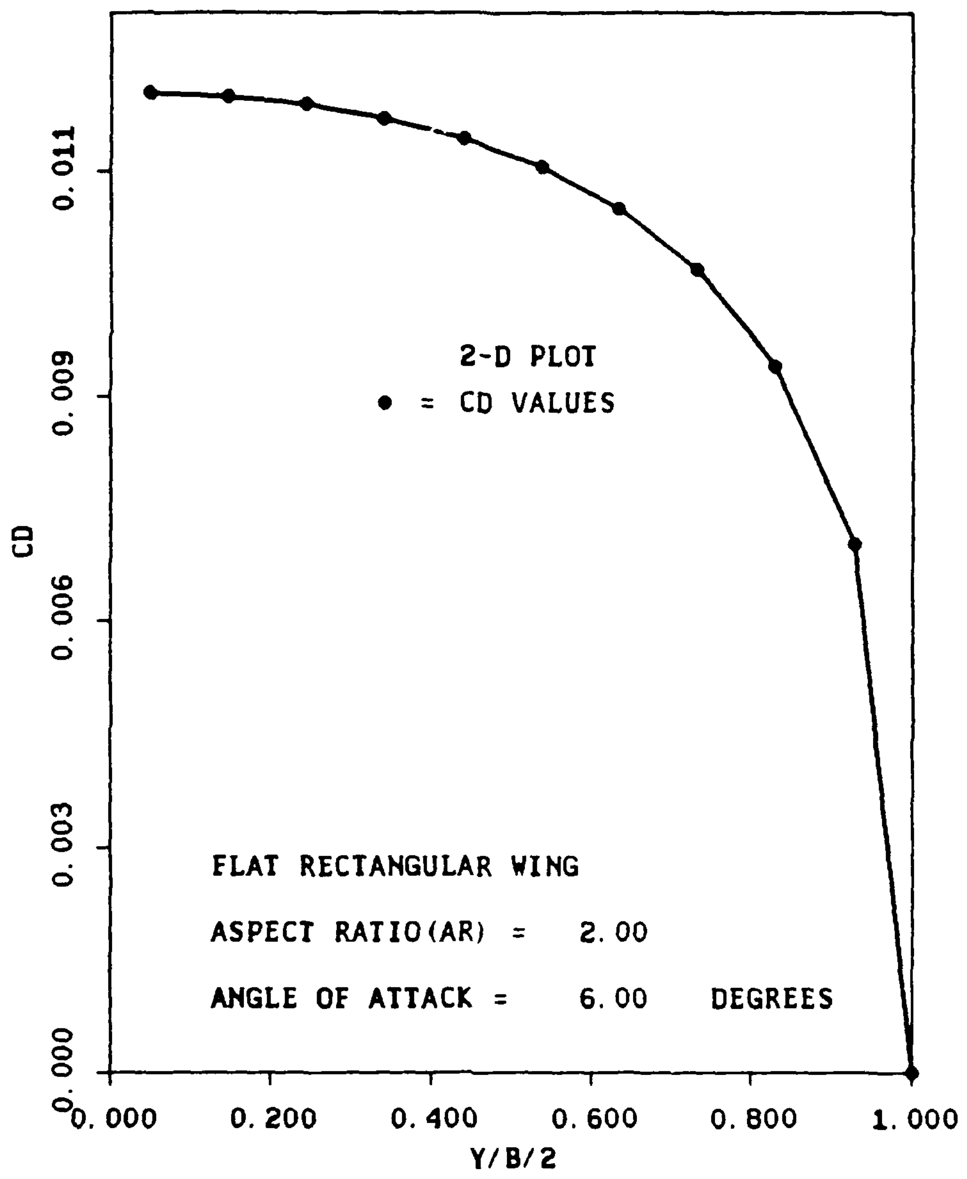


Figure 23. Cd vs. Y

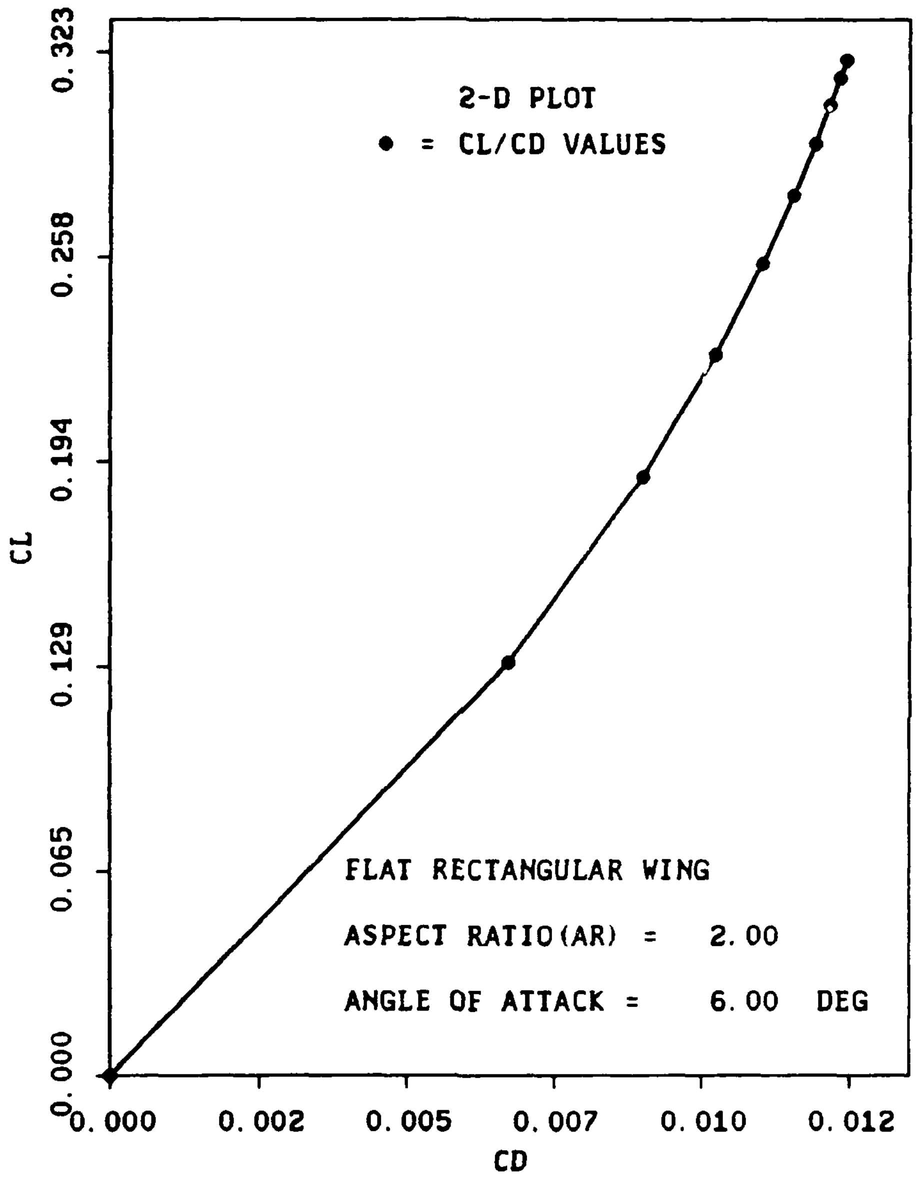


Figure 24. Cl vs. Cd

APPENDIX D
PROGRAM SUB USER'S MANUAL

USER'S GUIDE CONTENTS

I. INTRODUCTION

The SUB program has been adapted from a National Aeronautics and Space Administration (NASA) FORTRAN program and has been used considerably at the Langley Research Center. Additionally, this particular program has also been used in industry and the results have shown good correlation with experimental values. SUB has subsequently been revised to enhance its ease of use and its ability to present accurate graphical results.

The purpose of the SUB program is to estimate the subsonic aerodynamic characteristics of complex planforms. The program represents a lifting planform with a vortex lattice. A relatively complex planform may be analyzed by creating the planform with up to 24 line segments on a semispan. Additionally, these line segments may have an outboard variable-sweep panel or they may have several dihedral angles across the span. Furthermore, two planforms may be used together to represent a combination of wings and tails or wing, bodies, and tails.

II. ASSUMPTIONS AND LIMITATIONS

The use of this program is confined to the subsonic flow regime. Additionally, the planform is in steady, uniform, inviscid, incompressible, attached flow conditions.

Certain restrictions must also be kept in mind when using this program. Three specific restrictions apply to all planforms analyzed: 1) Only a total of two planforms may be specified; 2) The maximum number of horseshoe vortices on the left side must be limited to 120. When two planforms are specified, the sum total of the vortices is limited to 120. Within this limit, the number of horseshoe vortices in any chordwise row may vary from 1 to 20 and the number of chordwise rows may vary from 1 to 50, and 3) The left side of the planform must be described with less than 24 line segments.

Additionally, there are also three limitations which must be applied to variable-sweep planforms: 1) There should always be a fixed-sweep panel between the root chord and the outboard variable-sweep panel; 2) The pivot cannot be canted from the vertical, and 3) Dihedral considerations cannot be programmed for the variable-sweep panel or at the intersection of this panel with the fixed portion of the wing.

Finally, there exists three limitations when considering planforms which have nonzero dihedral angles or to two planforms which do not lie in the same plane: 1) The variation in local chord must be continuous from the tip chord to the root chord of each planform specified; 2) The number of horseshoe vortices in each chordwise row must be at least two, and 3) The number of horseshoe vortices must be constant over the semispan of each planform.

III. INPUT DESCRIPTION

There are relatively few input values required for this program. Their description and program variable names are listed below. The user's first task before running this program will be to create an input data file corresponding to the respective planform to be analyzed and the desired program specifications. Each line of the input file is detailed explicitly.

A. GROUP ONE DATA

Line 1

PLAN	Number of planforms for the configuration.
TOTAL	Number of sets of group two data (normally one).
CREF	Reference chord of the configuration (greater than zero).
SREF	Reference area of the configuration (greater than zero).

Line 2

AAN(IT)	Number of line segments used to describe the left half of the planform.
XS(IT)	X location of the pivot; use 0 on a fixed wing.
YS(IT)	Y location of the pivot; use 0 on a fixed wing.
RTCDHT(IT)	Vertical distance of the particular planform being read in with respect to the wing root chord height; use 0.

** The next series of input data lines are used to describe each line segment which was used to specify the planform shape. In other words, if one has used five line segments to describe his or her planform, the next five lines will describe each line segment respectively. The first break-point is located at the intersection of the left wing leading edge with the root chord. They are numbered in increasing order for each intersection of lines in a counterclockwise direction. The input variables for each of these lines is as follows:

Lines 3-Whatever

XREG(I,IT)	X location of the ith breakpoint.
YREG(I,IT)	Y location of the ith breakpoint.
DIH(I,IT)	Dihedral angle (degrees) in y-z plane of line from breakpoint; positive upward.

AMCD	The move code. (This input indicates whether or not the line segment in question is on a movable panel. Use 1 for a line which is fixed or 2 for a line which is movable.

B. GROUP TWO DATA

Depending upon planform specifications, group two data could consist of three sections. The first section is always included. The second section is to be used if the number of chordwise horseshoe vortices varies across the semispan. One reason to vary the number of chordwise vortices across the semispan would be the need to analyze specific portions of the wing which may experience great pressure gradients i.e. at the intersection point of the fixed and the movable planforms for a variable sweep wing. The third section is used when the wing has twist and/or camber distribution and may consist of up to 15 lines, depending upon the number of horseshoe vortices.

Line 1 (Section One)

CONFIG	An arbitrary configuration number (up to four digits)—user's choice.
SCW	The number of chordwise horseshoe vortices to be used to represent the wing; a maximum value of 20 may be used. If the user desires that the number of chordwise vortices vary across the semi span, enter 0. Entering zero will require the use of section two of Group Two data. The SCW = 0 option can only be used on wings without dihedral and for coplanar wing-tail configurations.
VIC	The number of spanwise rows at which chordwise horseshoe vortices will be TBLSCW(I) cannot exceed 120.
MACH	Mach number. A value other than 0 will cause the Prandtl-Glauert compressibility factor to be applied. Regardless, the Mach number should be less than the critical Mach number.

CLDES	Desired Lift Coefficient. Used to obtain the span load distribution at a particular lift coefficient. If this aspect is not required enter 1. Enter 11 for drag polar data.
PTEST	If the damping-in-roll parameter is desired, enter 1.
QTEST	If CLq or Cmq stability derivatives are desired, enter 1. However, PTEST and QTEST cannot both be done in the same program run.
TWIST(1)	Twist code for the first planform. Enter 0 for no twist. Enter 1 if the planform has twist and provide data in section three.
SA(1)	Variable sweep angle for the first planform. Specify the leading-edge sweep angle (degrees) for the first movable line adjacent to the fixed portion of the planform. For a fixed planform, this quantity may be omitted.
TWIST(2)	Twist code for the second planform.**
SA(2)	Variable sweep angle for the second planform.**

**Obviously, these inputs may be omitted if there is only one planform.

Line 2 (Section Two)

Again, section two is to be used if SCW was set to 0 thus allowing for the number of chordwise horseshoe vortices to vary across the semispan.

STA	Total number of spanwise rows of horseshoe vortices per semispan. This input sets the number of values to be read into TBLSCW(I)—next input.

Lines 3-Whatever

TBLSCW(I)	Number of horseshoe vortices in each row starting at the row near the tip of the first planform and proceeding to the row near the root. If a second planform has been specified, the table of chordwise rows concludes with the number of vortices specified for the second planform (see Example B for format).

Section Three

Again, section three is to be used if the planform has twist.

ALP(NV)	Local angle of attack in radians. Refer to Example Three (3)
FORMAT	Refer to the sample input data files on how to properly format the input data files. *Failure to follow these examples implicitly will result in a "data read error".*

IV. SAMPLE PROBLEMS

Three sample problems have been included in this user's guide section. The first two problems analyze a fixed planform without a variable-sweep panel. The first problem simply uses four (4) spanwise vortices while the second problem uses 40 spanwise vortices. The second problem demonstrates the benefit of using extra horseshoe vortices to enhance data representation. The last problem is an example of a rather complex planform. This particular wing has variable chordwise vortices across seven (7) spanwise rows and has twist incorporated into the wing. Additionally, this wing is described using 14 line segments.

V. STARTING THE PROGRAM

Begin with the screen showing the DCL prompt, which looks like this:

```
$
```

Next, enter the following command:

```
SET DEF [.SUB]
```

Now, enter the command to run the program:

```
RUN SUB
```

The program will start and the screen should look similar to what is shown is Figure 25.

```
PROGRAM MLVL - SUBSONIC VORTEX LATTICE ANALYSIS

ENTER INPUT DATA FILE NAME

USE LAST.END AS DATA FILE NAME TO STOP THE PROGRAM
```

Figure 25. Initial Screen for Program SUB

VI. SAMPLE GRAPHIC OUTPUTS

A. EXAMPLE PROBLEM 1

Enter the name of the input data file.

A9WS60.DAT [Return]

Once the program has finished its data tabulations, your screen should be similar to Figure 26.

```
PROGRAM RESULTS HAVE BEEN WRITTEN TO THE FILE
                OUTFILE.DAT.

WOULD YOU LIKE A PRINTED COPY OF THIS OUTPUT FILE?
               YES OR NO (Y/N)
```

Figure 26. Printing Determination Screen

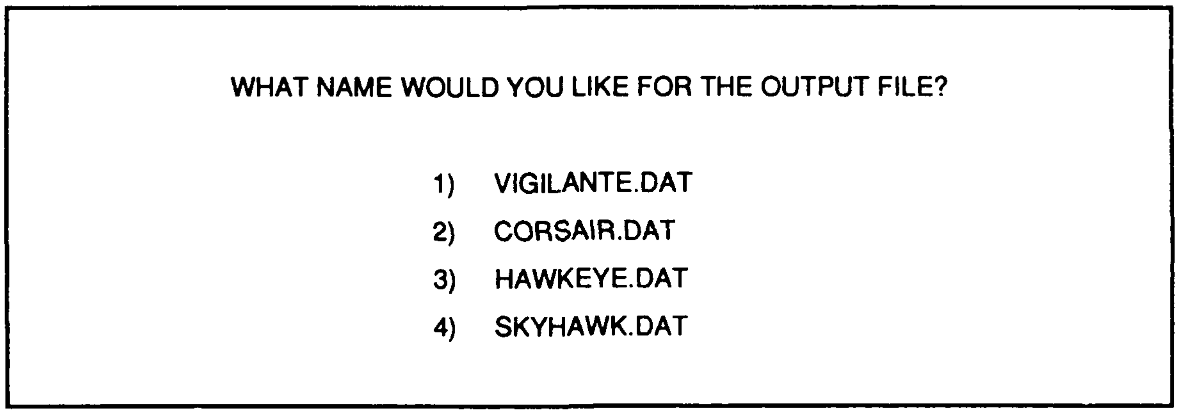
Respond negatively to this request by typing:

N [Return]

Respond affirmatively to the request to copy the output data file (OUTFILE.DAT) to another file by typing:

Y [Return]

A screen similar to Figure 27 will then appear which lists the file choices possible for copying.



```
WHAT NAME WOULD YOU LIKE FOR THE OUTPUT FILE?

        1)   VIGILANTE.DAT
        2)   CORSAIR.DAT
        3)   HAWKEYE.DAT
        4)   SKYHAWK.DAT
```

Figure 27. Output File Designation Screen

Select from the designated list of file names your choice.

1,2,3, OR 4 [Return]

Respond affirmatively to the request to graph the results by typing:

Y [Return]

The screen should now look like Figure 28.

```
          WHICH OF THE FOLLOWING RELATIONSHIPS
                 DO YOU WANT PLOTTED?

           1)  INDUCED DRAG COEFF VS. 2Y/B
           2)  LE EDGE THRUST COEFF VS. 2Y/B
           3)  SUCTION COEFF VS. 2Y/B
           4)  SPAN LOAD COEFF VS. 2Y/B
           5)  CL RATIO VS 2Y/B
           6)  NONE

            INPUT OPTION NO. (1,2,3,4,5, OR 6)
```

Figure 28. Plot Determination Screen

Select from the designated list of graphical relationships your choice.

1,2,3,4, OR 5 [Return]

The requested plot will momentarily appear on your screen. If you have remoted your terminal to terminal "KELLY" for printing purposes your plot will come up on the "KELLY" monitor. Compare your plot with the example plots corresponding to EXAMPLE 1; it should be the same.

Respond negatively to the request to print the plot by typing:

N [Return]

The user will again be given the opportunity to graph another relationship (Figure 28 will be presented). Respond with the 6th choice to exit the graphing loop. Enter:

6 [Return]

The program now asks if you want to make another run. Enter

1 [Return]

B. EXAMPLE PROBLEM 2

The screen should again look like Figure 25.

Enter the name of the input data file.

E9WS60.DAT [Return]

Respond negatively to the request for a printed copy of the output file by typing:

N [Return]

Respond negatively to the request to copy the output data file (OUTFILE.DAT) to another file by typing:

N [Return]

Respond affirmatively to the request to graph the results by typing:

Y [Return]

Again, Figure 28 will appear on your screen with a listing of the available plotting routines.

Select from the list your plotting choice.

1,2,3,4, OR 5 [Return]

The requested plot will momentarily appear on your screen. Again, if you have remoted your terminal to terminal "KELLY" for printing purposes your plot will come up on the "KELLY" monitor. Compare your plot with the example plots corresponding to EXAMPLE 2; it should be the same.

Respond negatively to the request to print the plot by typing:

N [Return]

The user will again be given the opportunity to graph another relationship. Respond with the 6th choice to exit the graphing loop. Enter:

6 [Return]

Respond affirmatively to the request to perform another run of program by typing:

1 [Return] **

**Entering a "2" would exit the user from the program.

C. EXAMPLE PROBLEM 3

Enter the name of the input data file.

B9WS60.DAT [Return]

Respond negatively to the program request to print OUTFILE.DAT. Enter:

N [Return]

Respond negatively to the request to copy the output data file (OUTFILE.DAT) to another file by typing:

N [Return]

Respond affirmatively to the request to graph the results by typing:

Y [Return]

Select from the designated list of graphical relationships your choice.

1, 2, 3, 4, OR 5 [Return]

The requested plot will then appear on your screen and you will be asked if you want to print the plot. Compare your plot with the example plots corresponding to EXAMPLE 3; it should be the same.

Respond negatively to the request to print the plot by typing:

N [Return]

The user will again be given the opportunity to graph another relationship. Respond with the 6th choice to exit the graphing loop. Enter:

6 [Return]

Respond negatively to the request to perform another run of program by typing:

2 [Return]

This completes the sample problems for the SUB program. Graphical output examples created by these sample runs are shown in Figures 29 through 34. The first five plots were generated from the analysis of a wing with an aspect ratio of nine and a leading edge sweep angle of 60°. The last plot (Figure 34) was produced from the analysis of a rather complex planform [Ref. 6], which had seven rows of spanwise vortices with nine vortices across the chord at horseshoe vortex Number 3.

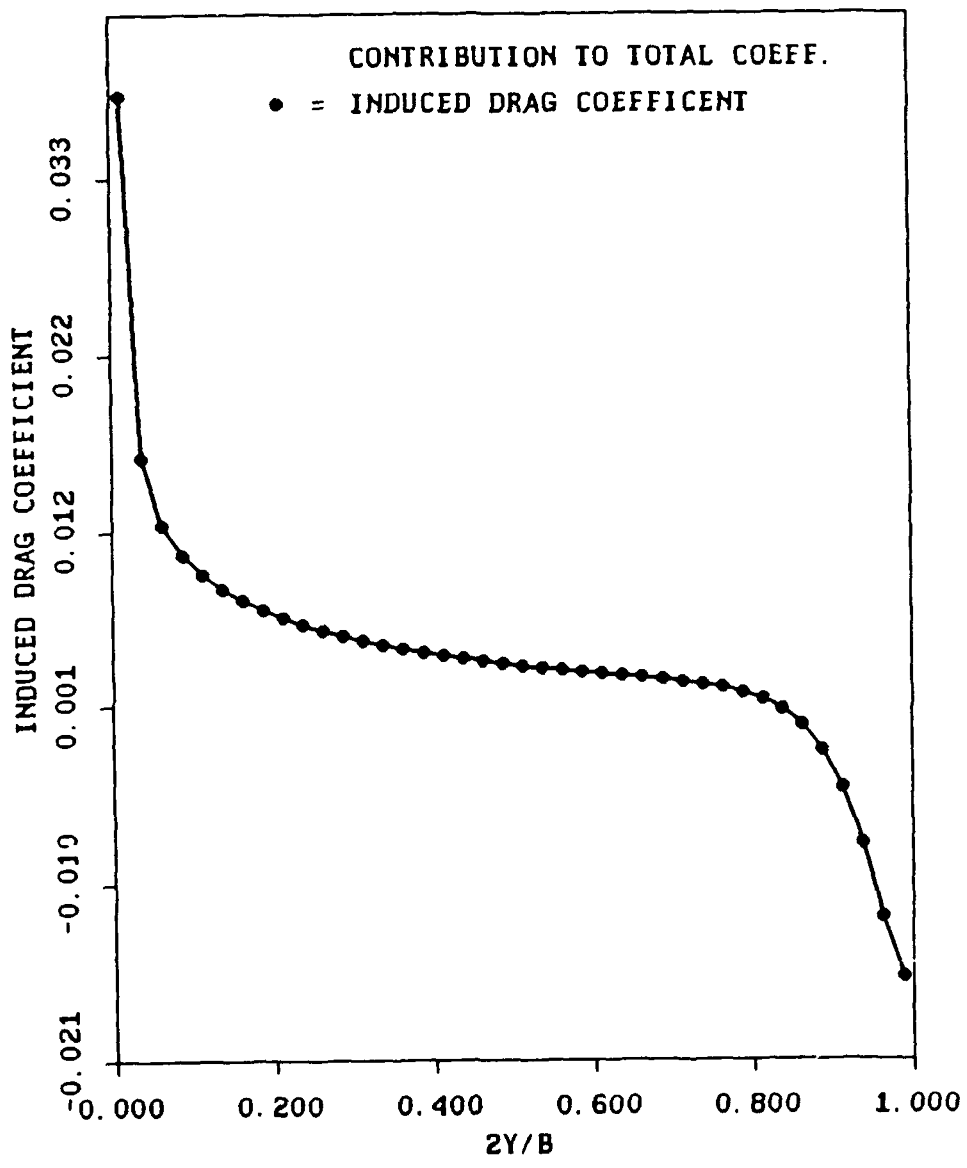


Figure 29. Induced Drag Coeff. vs. 2Y/B

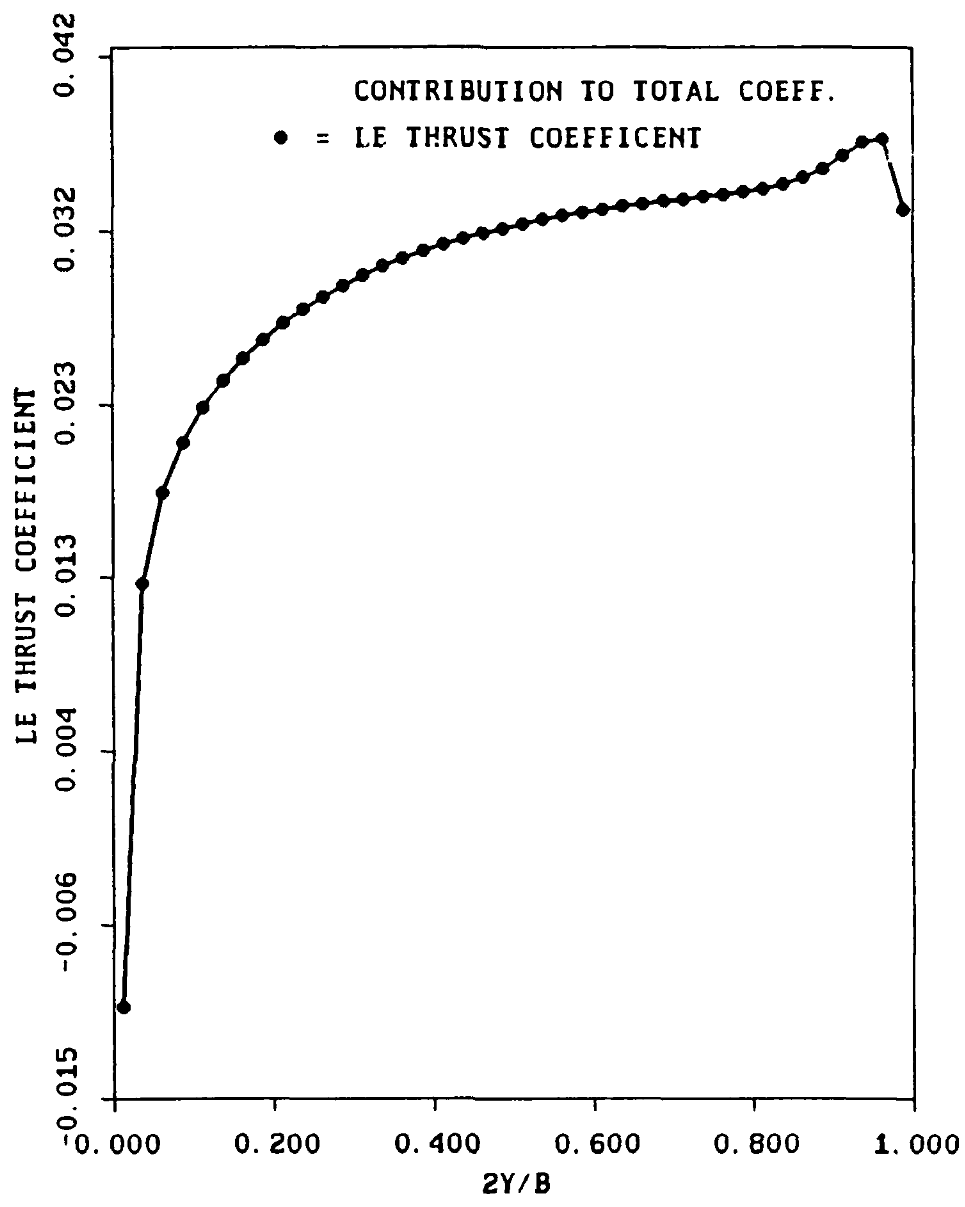


Figure 30. LE Thrust Coeff. vs. 2Y/B

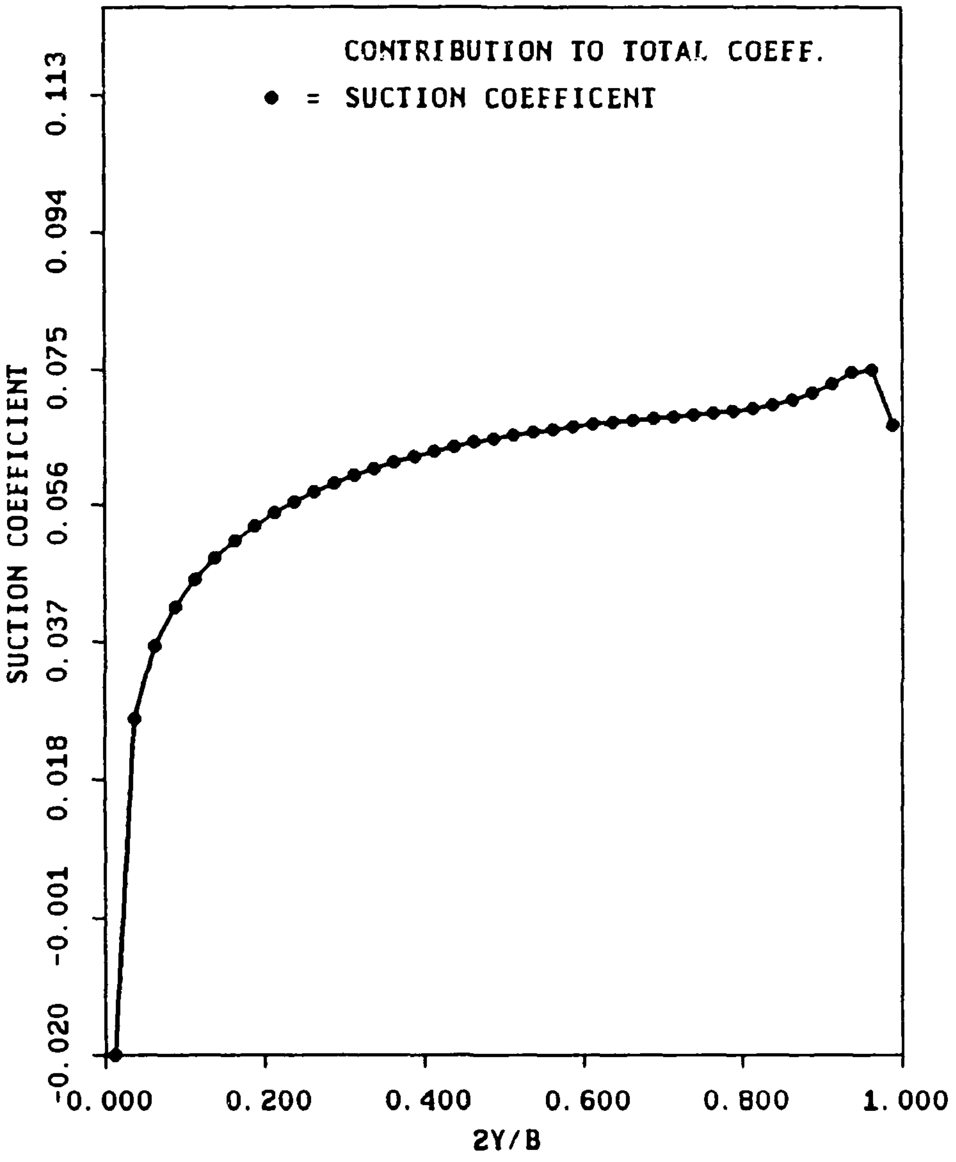


Figure 31. Suction Coeff. vs. 2Y/B

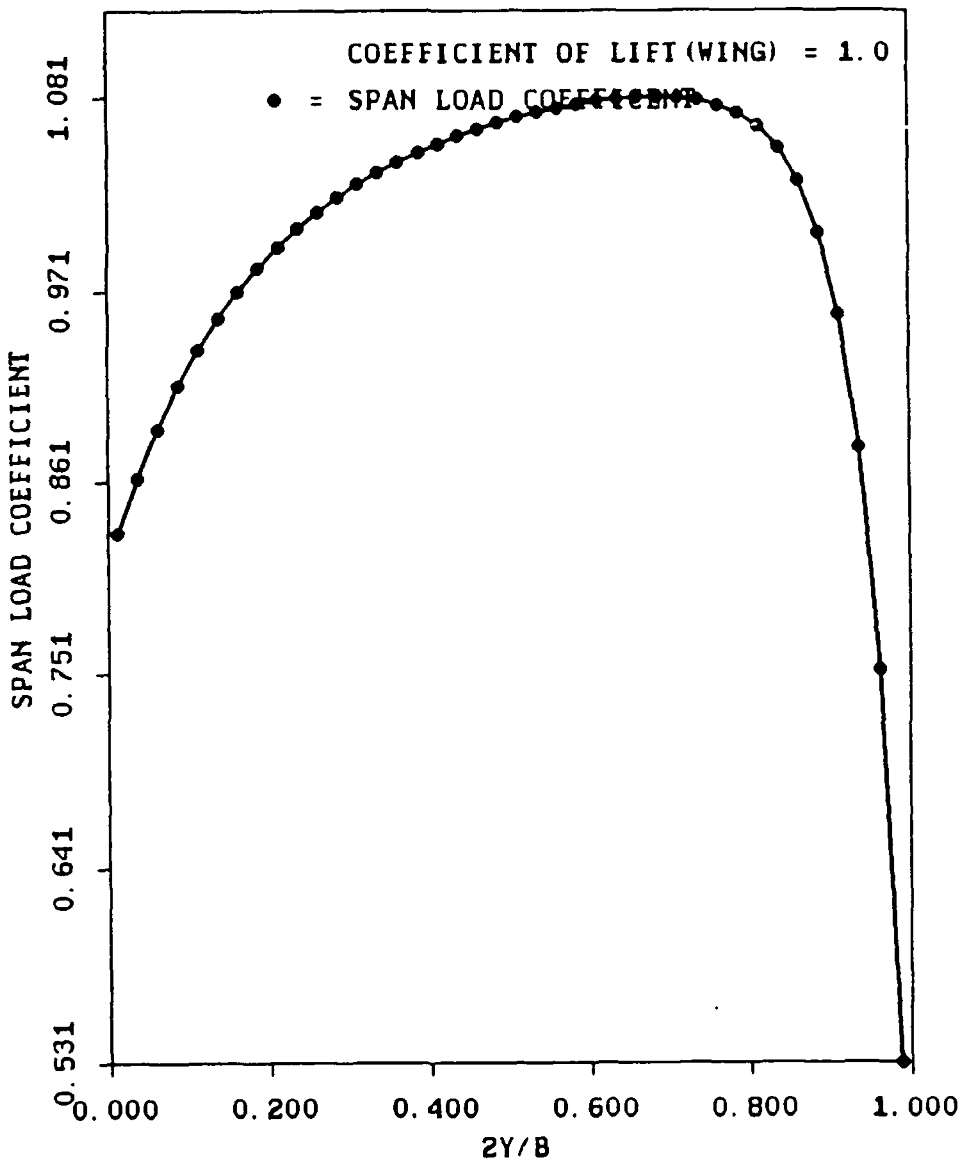


Figure 32. Span Load Coeff. vs. 2Y/B

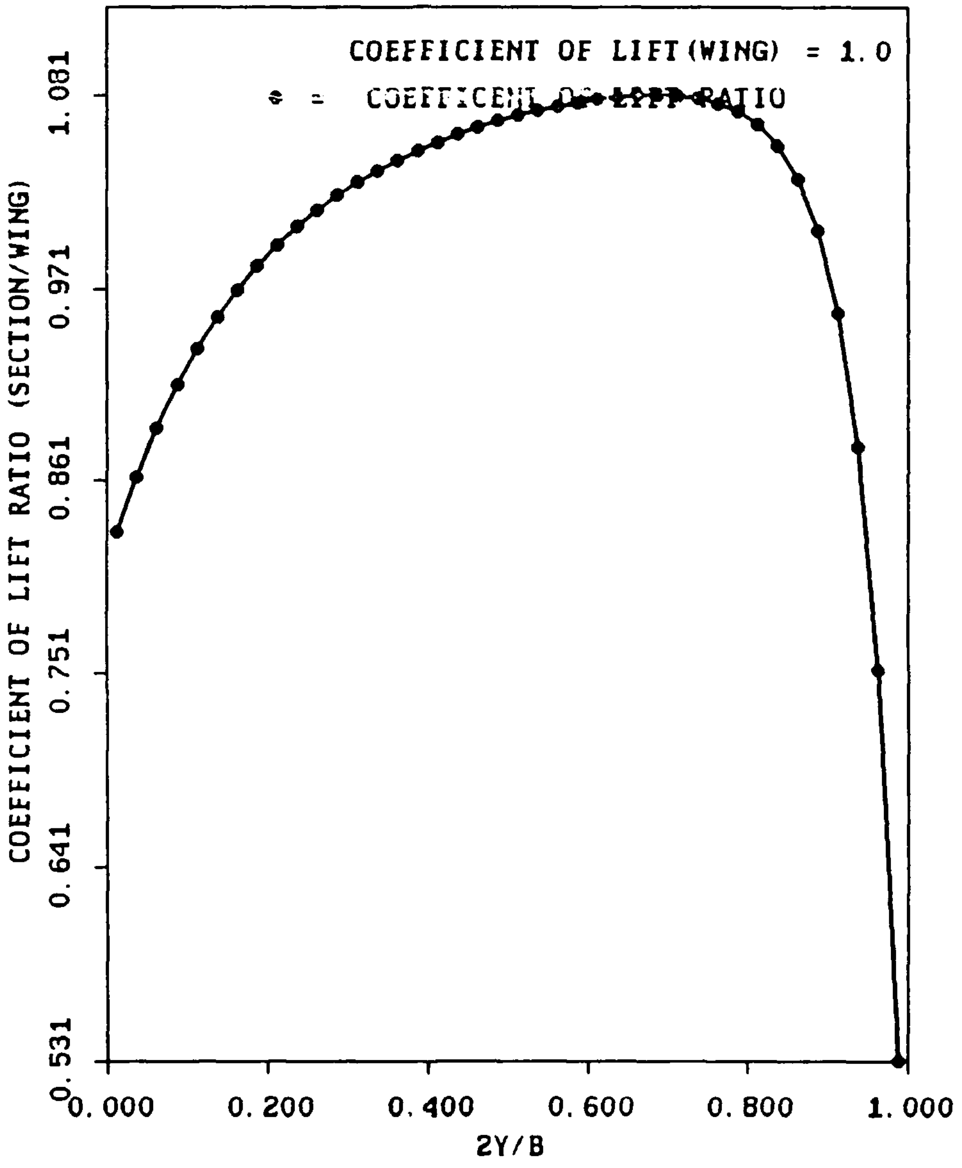


Figure 33. Coeff. of Lift Ratio vs. 2Y/B

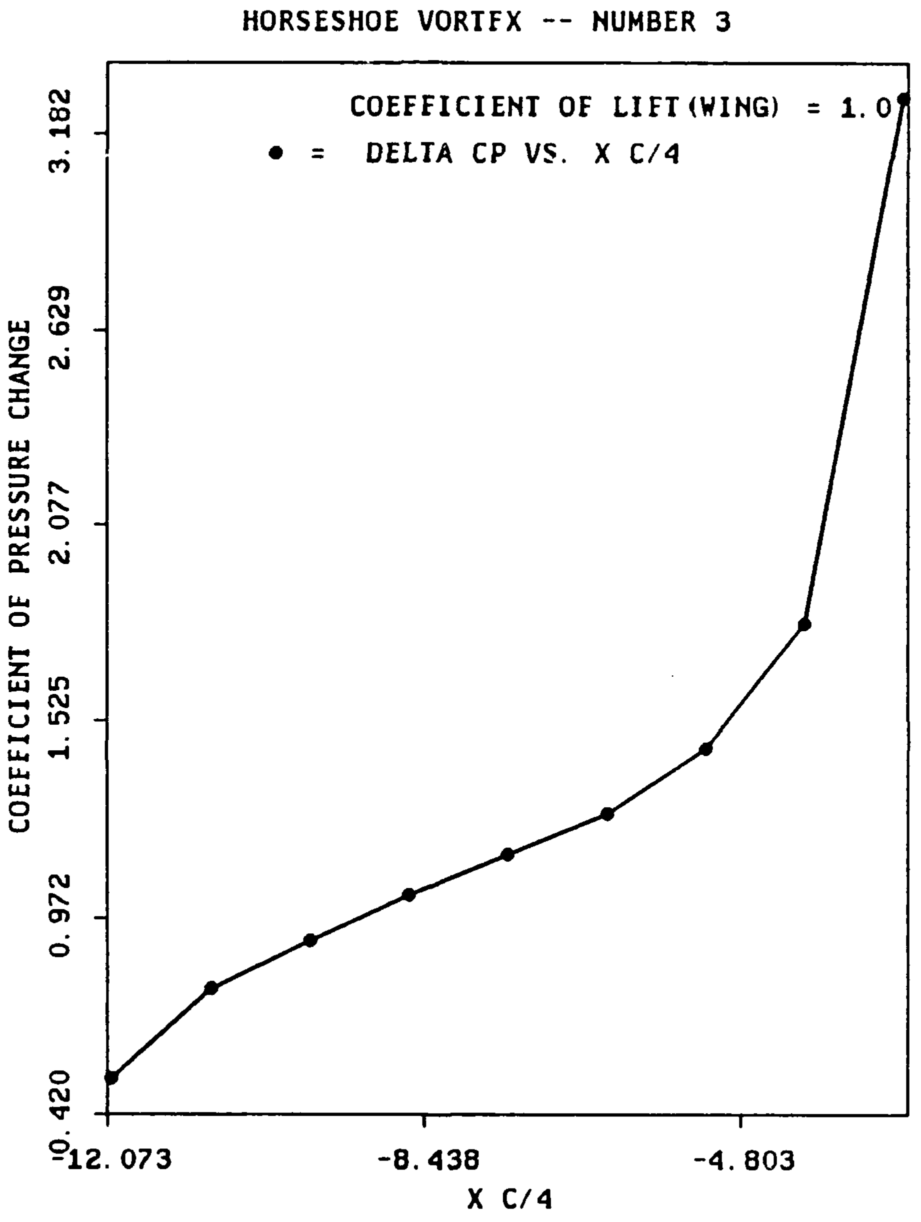


Figure 34. Delta Cp vs. X c/4

APPENDIX E
PROGRAM SUPER USER'S MANUAL

USER'S GUIDE CONTENTS

I. INTRODUCTION

The SUPER program has been adapted from a National Aeronautics and Space Administration (NASA) FORTRAN program and has been used considerably at the Langley Research Center. Additionally, this particular program has also been used in industry. The results have shown good correlation with experimental results. SUPER has subsequently been revised to enhance it's ease of use and its ability to present accurate graphical results.

The purpose of the SUPER program is to estimate the supersonic aerodynamic characteristics of complex planforms. Linearized supersonic lifting surface theory is employed to calculate the aerodynamic characteristics of a warped wing of arbitrary planform. The program calculates lifting pressure distribution for the chordwise warped wing at fixed attitude and the pressure distribution (per degree angle of attack) for a corresponding flat wing. These two pressure distributions are combined by superposition principles and integrated over the wing surface to obtain the variation of aerodynamic characteristics with changes in angle of attack.

II. ASSUMPTIONS AND LIMITATIONS

The use of this program is confined to the supersonic flow regime. In addition, the linearized supersonic lifting surface theory, used in this program, applies to wings having negligible thickness.

There exist two specific limitations which must be considered when entering the respective input data values. The number of semispan grid elements is limited to 100 or 47.5*B*SPAN/XMAX. The relative increase in semispan grid elements will increase the computational time of the program. Additionally, the number of percent chord values is limited to 26. Lastly, there are a few other input restrictions which need to be referenced when creating your input data file. The next section delineates each respective input and declares any restrictions.

III. INPUT DESCRIPTION

There are relatively few input values required for this program. Their description and program variable names are listed below. The user's first task before running this program will be to create an input data file corresponding to the respective planform to be analyzed and the desired program specifications.

LINE 1:	**$INPT1**	
	Type line as indicated. This lines cues the program for input of data.	
LINE 2:	**XM**	=
	Mach Number of freestream.	
LINE 3:	**NOM**	=
	Number of additional Mach Numbers other than XM ($NOM \leq 5$).	
LINE 4:	**NOPCT**	=
	Number of percent chord values for TZORD input ($NOPCT \leq 26$).	
LINE 5:	**TPCT**	=
	Table of percent chord values, corresponding to NOPCT, in increasing order from 0 to 100.	
LINE 6:	**JBYMAX**	=
	Number of spanwise stations at which TZORD is to be specified ($JBYMAX \leq 51$).	

LINE 7: **TYB2** =

Table of semispan fractions, corresponding to JBYMAX, in increasing order from 0 to 1.0.

LINE 8: **TZORD** =

Z_C coordinates of right-hand wing panel corresponding to TYB2 and TPCT. All values of z_C at a given semispan station entered in order according to TPCT, 26 values required to fill a table column. You must enter 26 values per column although only NOPCT values are used. After the first column is filled, repeat with other TYB2 stations, proceeding to right-hand wing tip.

LINE 9: **REFAR** =

Wing reference area.

LINE 10: **SPAN** =

Total wing span.

LINE 11: **XLEO** =

X coordinate of wing leading edge of y=0.

LINE 12: **XTEO** =

X coordinate of wing trailing edge at y=0.

LINE 13: **XMAX** =

Largest value of x in wing definition.

LINE 14: **XO** =

Distance from some arbitrary location to wing apex. XO=0. if you are considering the wing only. This term is used in locating streamwise lift distribution with respect to XO rather than wing apex.

LINE 15: **TYPEX** =

= 0. Input TTXLE and TXTE tables.

= 1. Input NLEX, NTEX and tables of TBLEX, TBLEY, TBTEX, TBTEY.

LINE 16: **TXLE** =

Table of wing leading edge x coordinates at successive values of y=((SPAN/2)/NON)*N where N = 1, 2, 3, ...NON. (Omit if TYPEX = 1.)

LINE 17: **TXTE** =

Table of wing trailing edge x coordinates specified at same values of y as TXLE. (Omit if TYPEX = 1.)

LINE 18: **NLEX** =

Number of leading edge (x;y) points to be input (NLEX≤15). (Omit if TYPEX = 0.)

LINE 19: **NTEX** =

Number of trailing edge (x,y) points to be input (NTEX≤15). (Omit if TYPEX = 0.)

LINE 20: **TBLEX** =

Table of NLEX leading edge x values(spanwise, root to tip).(Omit if TYPEX =0.)

LINE 21: **TBLEY** =

Table of NLEX leading edge y values(spanwise, root to tip).(Omit if TYPEX =0.)

LINE 22: **TBTEX** =

Table of NTEX trailing edge x values(spanwise, root to tip).(Omit if TYPEX =0.)

LINE 23: **TBTEY** =

Table of NTEX trailing edge y values(spanwise, root to tip).(Omit if TYPEX =0.)

LINE 24: **CBAR** =

Reference length used for pitching moment coefficient.

LINE 25: **XMREF** =

X distance from X=0. locating pitching moment center.

LINE 26: NON =

Number of semispan grid elements selected to represent the wing. (NON≤50 or NON≤47.5*B*SPAN/XMAX (whichever value is less).

LINE 27: $END

Line statement ends input of data.

IV. SAMPLE PROBLEMS

Two sample problems have been included in this user's guide section. Both consider the same planform shape, but the input method of the planform shape is different. Only one set of plots exists in the sample problems output file section in that the two sets of plots are identical.

V. STARTING THE PROGRAM

Begin with the screen showing the DCL prompt, which looks like this:

```
$
```

Next, enter the following command:

```
SET DEF [.SUPER] [Return]
```

Now, enter the command to run the program:

```
RUN SUPER [Return]
```

The program will start and the screen should look similar to what is shown is Figure 35.

```
PROGRAM A4410 - SUPERSONIC VORTEX LATTICE ANALYSIS

ENTER THE INPUT FILE NAME
USE LAST.END AS THE DATA FILE NAME
TO STOP THE PROGRAM
```

Figure 35. Initial Screen for Program SUPER

VI. SAMPLE GRAPHICAL OUTPUTS

A. EXAMPLE PROBLEM 1

Enter the name of the input data file.

SSVL1.DAT [Return]

Once the program has finished its data tabulations, your screen should be similar to Figure 36.

```
PROGRAM RESULTS HAVE BEEN WRITTEN TO THE FILE
OUTFILE.DAT.

WOULD YOU LIKE A PRINTED COPY OF THIS OUTPUT FILE?

YES OR NO (Y/N)
```

Figure 36. Printing Determination Screen

Respond negatively to print request by typing:

N [Return]

Respond affirmatively to the request to copy the output data file (OUTFILE.DAT) to another file by typing:

Y [Return]

A screen similar to Figure 37 will then appear which lists the file choices possible for copying.

```
WHAT NAME WOULD YOU LIKE FOR THE OUTPUT FILE?

     1)  TOMCAT.DAT
     2)  PHANTOM.DAT
     3)  INTRUDER.DAT
     4)  CRUSADOR.DAT

ENTER 1, 2, 3 OR 4
```

Figure 37. Output File Designation Screen

Select from the designated list of file names your choice.

1,2,3, OR 4 [Return]

Respond affirmatively to the request to graph the results by typing:

Y [Return]

The screen should now look like Figure 38.

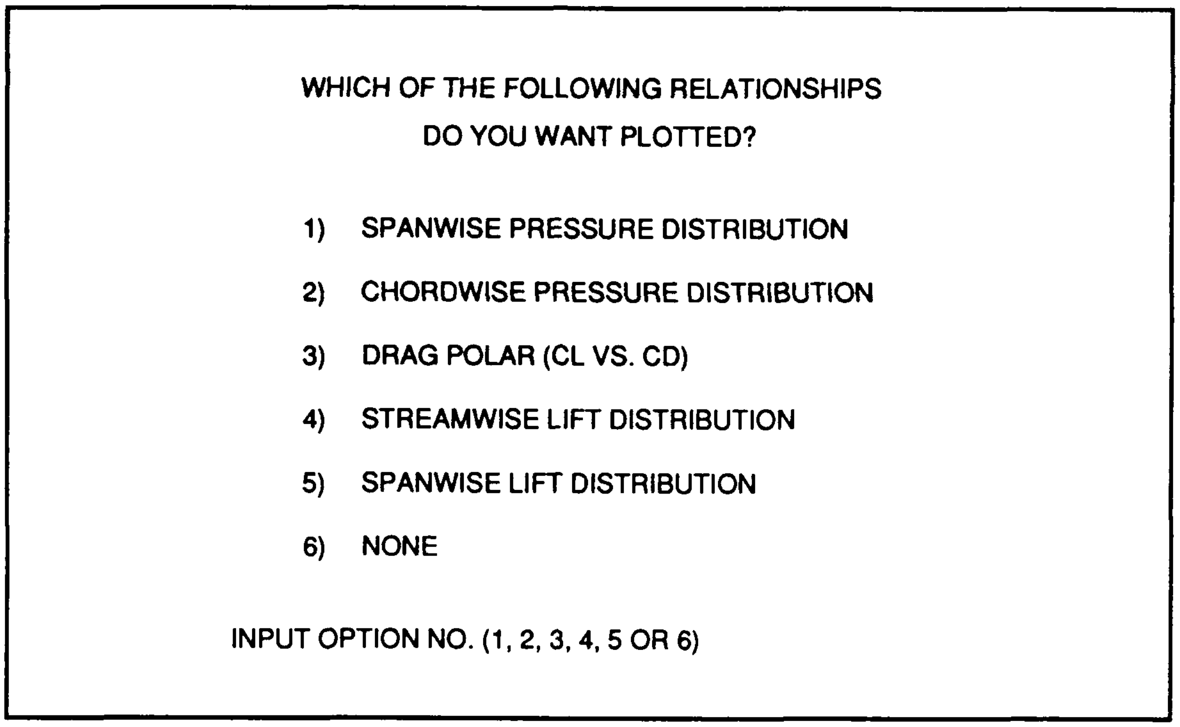

```
                WHICH OF THE FOLLOWING RELATIONSHIPS
                        DO YOU WANT PLOTTED?

                1)  SPANWISE PRESSURE DISTRIBUTION

                2)  CHORDWISE PRESSURE DISTRIBUTION

                3)  DRAG POLAR (CL VS. CD)

                4)  STREAMWISE LIFT DISTRIBUTION

                5)  SPANWISE LIFT DISTRIBUTION

                6)  NONE

            INPUT OPTION NO. (1, 2, 3, 4, 5 OR 6)
```

Figure 38. Plot Determination Screen

Select from the designated list of graphical relationships your choice.

1,2,3,4, OR 5 [Return]

The requested plot will then appear on your screen and you will be asked if you want to print the plot. If you have remoted your terminal to terminal "KELLY" for printing purposes your plot will come up on the "KELLY" monitor. Compare your plot with the example plots corresponding to SAMPLE # 1; it should be the same.

Respond negatively to the request to print the plot by typing:

N [Return]

The user will again be given the opportunity to graph another relationship (Figure 22 will be presented). Respond with the 6th choice to exit the graphing loop. Enter:

6 [Return]

The program now asks if you want to make another run. Enter

1 [Return]

B. EXAMPLE PROBLEM 2

The screen should again look like Figure 35.

Enter the name of the input data file.

EXPROB2.DAT [Return]

Respond negatively to the request for a printed copy of the output file by typing:

N [Return]

Respond negatively to the request to copy the output data file (OUTFILE.DAT) to another file by typing:

N [Return]

Respond affirmatively to the request to graph the results by typing:

Y [Return]

Again, Figure 38 will appear on your screen with a listing of the available plotting routines.

Select from the list your plotting choice.

1, 2, 3, 4, OR 5 [Return]

The requested plot will appear on your screen. Again, if you have remoted your terminal to terminal "KELLY" for printing purposes your plot will come up on the "KELLY" monitor. Compare your plot with the example plots corresponding to SAMPLE#2; it should be the same.

Respond negatively to the request to print the plot by typing:

N [Return]

The user will again be given the opportunity to graph another relationship. Respond with the 6th choice to exit the graphing loop. Enter:

6 [Return]

Respond negatively to the request to perform another run of program by typing:

2 [Return]

This completes the sample problems for the SUPER program. Graphical output examples created by these sample runs are shown in Figures 39 through 42. These plots were created from the analysis of a B2 Bomber planform at a Mach of 1.2. The span used was 200 feet with a planform reference area of 8260.4 ft^2. Thirty semispan grid elements were used to represent the wing.

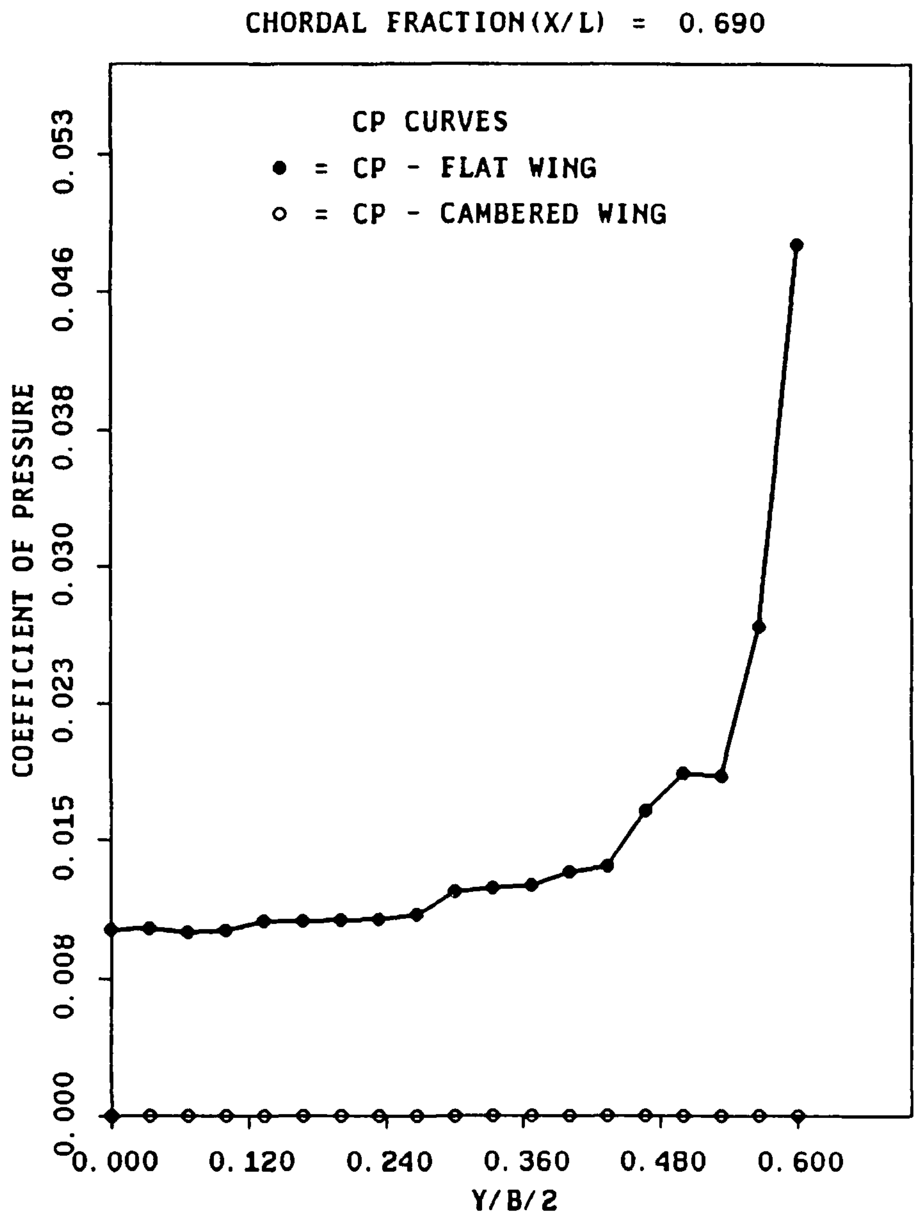


Figure 39. Spanwise Cp Distribution

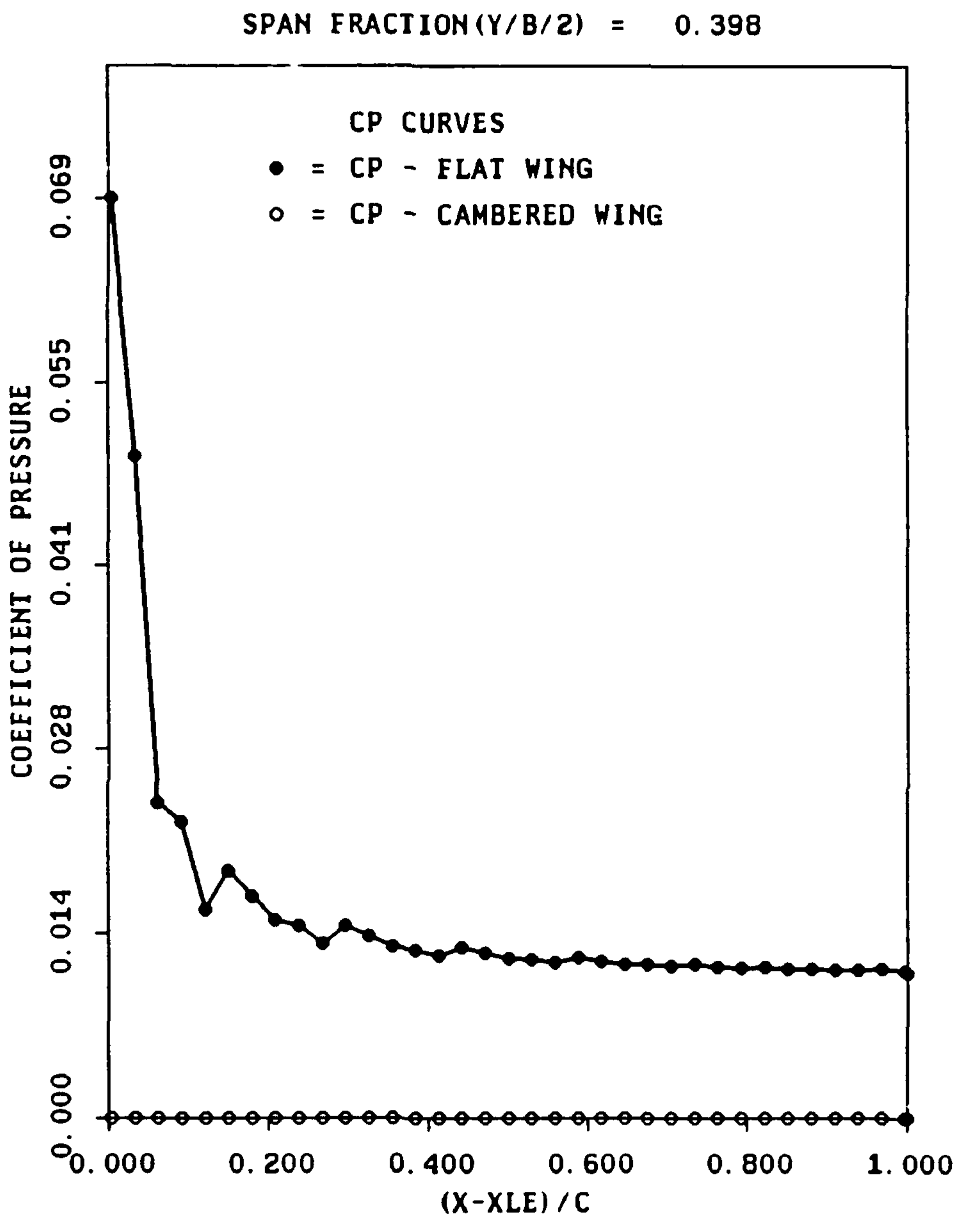


Figure 40. Chordwise Cp Distribution

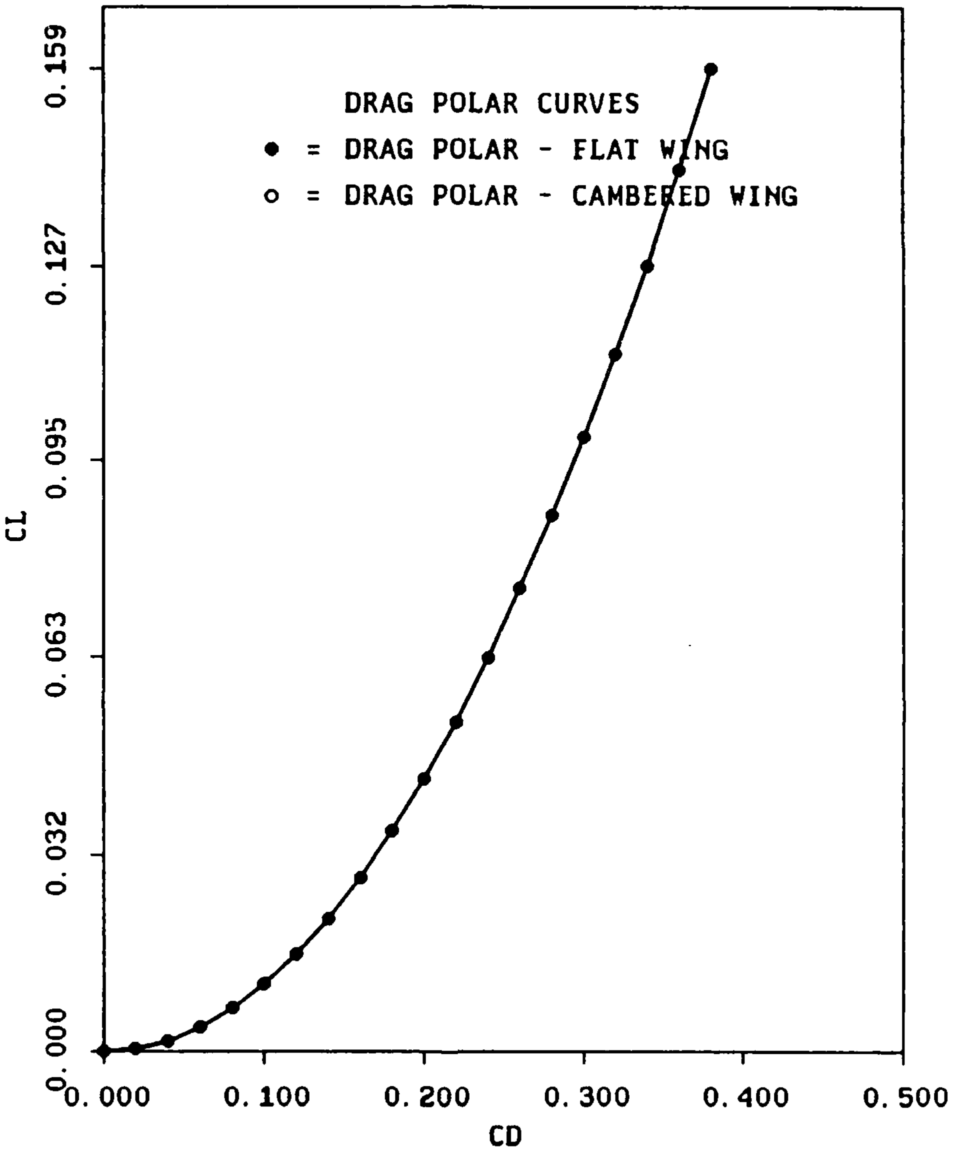


Figure 41. Drag Polar

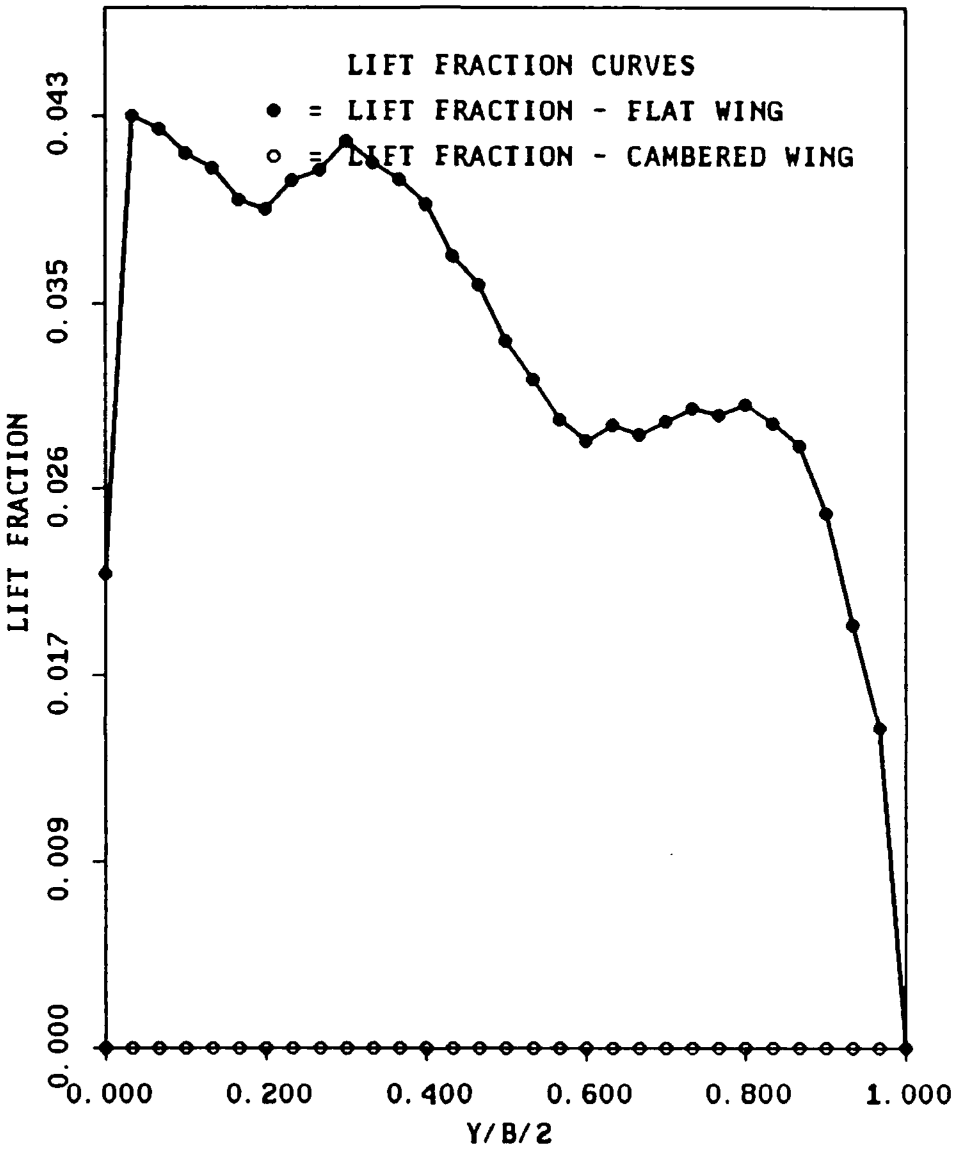


Figure 42. Spanwise Lift Distribution

APPENDIX F. PROGRAM NEW_DOUBLE COMPUTER CODE

```
      APPENDIX F.  PROGRAM NEW_DOUBLE COMPUTER CODE

      PROGRAM NEW_DOUBLE
C
C *** MODIFIED FOR USE ON THE MICROVAX/2000 BY J.A. CAMPBELL (JUL 88)
C     UPDATES MADE BY C.M.MACALLISTER JAN-JUL 89 (CMM)
C ********************************************************************
C
C        INCOMPRESSIBLE AERODYNAMICS OF SYMMETRIC AIRFOIL
C        AT ZERO ANGLE OF ATTACK BY LINE DOUBLET DISTRIBUTION
C
C     ORIGINAL IBM MAINFRAME PROGRAM WAS ADAPTED FROM JACK MORAN'S BOOK
C     'AN INTRODUCTION TO THEORETICAL AND COMPUTATIONAL AERODYNAMICS',
C     WILEY AND SONS, NEW YORK 1984.  THE LISTING IS FOUND ON PAGE 75.
C
C     PROGRAM FLEXIBILITY AND USER INTERFACE WAS REVISED FOR
C     PROFESSOR J.V. HEALEY BY JOHN CAMPBELL.
C     ADDITIONAL PROGRAM UPDATES TO INCLUDE DUBLET USE FOR ANY
C     ARBITRARY 2-D SHAPE, PRINTING ROUTINES, PROCESSING CORRECTIONS,
C     AND GRAPHICAL ANALYSIS WERE MADE BY CRAIG MACALLISTER IN
C     JAN-JUL 1989.  (CMM)
C
C ********************************************************************
C
      CHARACTER*1  IANS,PRINT,GRAPH,PLOT1,PLOT2,
     +PLOT3,CHECK,CORRECT
      INTEGER NANS,DATPO,PRINTOPT,GRAPHOPT
      REAL*4 T(100),M(100),XS,XF
      REAL XX,CP
      INTEGER N,R,NPRINT
      COMMON /GRAPH/XX,CP,NPRINT
      COMMON /MAIN/ T,M,N,XS,XF
      COMMON /GRAPHER/GRAPHOPT,XMAXY
      COMMON /FCN/AX,TAU,NTYPE
      COMMON /DATA/COORX(101),COORY(101)
      COMMON /PROB/DATPO
      DIMENSION NUM(100)
      REAL    MPLOT
C
C   OPEN FILE FOR DOUBLET STRENGTH DISTRIBUTION OUTPUT
      OPEN (UNIT=11,
     2      FILE= 'DUBLET.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2      STATUS= 'UNKNOWN')
C
C   OPEN FILE FQR BODY SHAPE OUTPUT
      OPEN (UNIT=12,
     2      FILE= 'SHAPE.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2      STATUS= 'UNKNOWN')
C
C   OPEN FILE FOR BODY SURFACE PRESSURE DISTRIBUTION OUTPUT
      OPEN (UNIT=13,
     2      FILE= 'PRESSURE.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2      STATUS= 'UNKNOWN')
C
C   OPEN ANOTHER FILE FOR BODY SURFACE PRESSURE DISTRIBUTION OUTPUT
      OPEN (UNIT=14,
     2      FILE= 'PRESS.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2      STATUS= 'UNKNOWN')
C
C   OPEN ANOTHER FILE FOR BODY SHAPE OUTPUT
      OPEN (UNIT=15,
     2      FILE= 'SHAPEBODY.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2      STATUS= 'UNKNOWN')
C
C
C  CALL LIBRARY ROUTINE TO CLEAR THE SCREEN, THE PRINT HEADER
    5 CONTINUE
      CALL CLRSCRN
      PRINT *
      PRINT *, ' PROGRAM DUBLET : VERSION 3 : 4 OCTOBER 89 '
      PRINT *
      PRINT *, ' DOUBLET DISTRIBUITON METHOD IS USED TO DETERMINE'
      PRINT *, ' INCOMPRESSIBLE AERODYNAMICS OF AN ELLIPSE, SYMMETRICAL'
      PRINT *, ' AIRFOIL OR ARBITRARY SYMMETRIC SHAPE AT ZERO ANGLE'
      PRINT *, ' OF ATTACK'
      PRINT *, ' '
      PRINT *, ' PROGRAM ASSUMES A NONDIMENSIONAL CHORD, THAT IS,'
      PRINT *, ' THE VALID RANGE OF X IS FROM 0 TO 1.'
      PRINT *
   10 PRINT *, ' ENTER TYPE OF BODY SHAPE DESIRED:    '
      PRINT *, '       1) ELLIPTIC'
      PRINT *, '       2) SYMMETRICAL AIRFOIL-LIKE OR'
      PRINT *, '       3) ARBITRARY SYMMETRIC SHAPE'
      PRINT *, ' ENTER 1, 2, OR 3.'
      PRINT *, ' '
      PRINT *, 'NOTE THAT OPTION 3 WILL REQUIRE MANUALLY INPUTTING DATA'
      PRINT *, 'POINTS FOR THE UPPER SIDE OF THE RESPECTIVE BODY'
   15 READ (5,*)  NTYPE
      IF (NTYPE .LT. 1 .OR. NTYPE .GT. 3)  THEN
          PRINT *, '   INVALID ENTRY. ENTER 1, 2, OR 3.'
```

```
            GO TO 15
        END IF
        IF (NTYPE .EQ. 3) THEN
            CALL CLRSCRN
            PRINT *, 'HOW MANY UPPER PROFILE DATA POINTS DO'
            PRINT *, 'YOU DESIRE? (ENTER A NUMBER BETWEEN 3 AND 100)'
            PRINT *, ' '
            PRINT *, 'BE AWARE THAT THE LEADING EDGE OF YOUR DESIRED'
            PRINT *, 'SHAPE HAS BEEN PROGRAMMED TO BE AT THE ORIGIN'
            PRINT *, 'AND THAT YOUR TRAILING EDGE IS AT (1,0).  SCALE'
            PRINT *, 'YOUR SHAPE/OBJECT ACCORDINGLY.'
            PRINT *, ' '
     17 READ (5,*) DATPO
        IF (DATPO .LT. 3 .OR. DATPO .GT. 100) THEN
            PRINT *, 'INVALID ENTRY. ENTER A NUMBER BETWEEN'
            PRINT *, 'THREE(3) AND 100 INCLUSIVE.'
            GO TO 17
        END IF
        DO 26 R = 1,DATPO
            COORX(1) = 0.0
            COORX(DATPO+2) = 1.0
            WRITE (5,27) R
     27 FORMAT (1X,'ENTER X(',I2,')')
            READ (5,*) COORX(R+1)
            COORY(1) = 0.0
            COORY(DATPO+2) = 0.0
            WRITE (5,28)R
     28 FORMAT (1X,'ENTER Y(',I2,')')
     READ (5,*) COORY(R+1)
     26 CONTINUE
        PRINT *,  ' '
        PRINT *,  ' WOULD YOU LIKE TO CHECK YOUR SURFACE DATA POINTS? '
        PRINT *, '                         (Y/N)'
        READ 1002, CHECK
        IF (CHECK.EQ.'Y'.OR.CHECK.EQ.'y')THEN
313       CALL CLRSCRN
          DO 65 I = 1,DATPO+2
            WRITE(5,29) I,COORX(I),COORY(I)
29          FORMAT(5X,I3,3X,F8.4,3X,F8.4,/)
65        CONTINUE
        PRINT *, ' WOULD YOU LIKE TO MAKE ANY CORRECTIONS?'
        PRINT *, '                (Y/N)'
        PRINT *, ' '
        READ 1002, CORRECT
        IF (CORRECT.EQ.'Y'.OR.CORRECT.EQ.'y')THEN
          PRINT *, ' '
          PRINT *, '  WHICH DATA POINT WOULD YOU LIKE TO CORRECT?'
          NUMBERS = DATPO + 2
          WRITE (5,30)NUMBERS
30        FORMAT (5X,'ENTER A NUMBER 1 THRU',I4,' INCLUSIVE')
312       READ (5,*)NUMCOR
          IF (NUMCOR.LT.1.OR.NUMCOR.GT.NUMBERS)THEN
           PRINT *, '  INVALID ENTRY  '
           WRITE (5,30)NUMBERS
           PRINT *, ' '
           GO TO 312
          ENDIF
        WRITE (5,27)NUMCOR
        READ(5,*)COORX(NUMCOR)
        WRITE (5,28)NUMCOR
        READ(5,*)COORY(NUMCOR)
        GO TO 313
        ENDIF
        ENDIF
        GO TO 70
        END IF
        PRINT *,'   ENTER THICKNESS RATIO (TAU).'
        READ (5,*) TAU
        IF (NTYPE .GT  1) THEN
           PRINT *
           PRINT *,'   ENTER THE NONDIMENSIONAL X LOCATION OF MAXIMUM',
     +     ' THICKNESS.'
   20      READ (5,*) XMAXY
        IF (XMAXY .GT. 0.5) THEN
           PRINT *,'   THE PROGRAM CONSIDERS THE ONSET FLOW TO BE'
           PRINT *,'   APPROACHING FROM THE LEFT.  THEREFORE, THE'
           PRINT *,'   X LOCATION OF MAXIMUM THICKNESS MUST BE < 0.5.'
           PRINT *,'   ==>  PLEASE REENTER.'
           GO TO 20
        END IF
           AX = (.5 * TAU)/(SQRT(XMAXY)*(1. - XMAXY))
        END IF
C
C          INPUT NUMBER OF INTERVALS N
C
 70     CALL CLRSCRN
        PRINT *
        PRINT *,  ' ENTER NUMBER OF INTERVALS DESIRED. N ='
 71     READ (5,*)   N
        PRINT *
        IF(N .LT. 2 .OR. N .GT. 100) THEN
           WRITE(6,21) N
           PRINT *, '    A MINIMUM OF TWO INTERVALS AND A MAXIMUM OF'
           PRINT *, '    100 IS ALLOWED. ===>  PLEASE REENTER.'
           GO TO 71
        END IF
   21 FORMAT(1X,5X,'NUMBER OF INTERVALS REQUESTED =',I3)
C
C   ASK USER FOR AUTOMATIC OR MANUAL DETERMINATION OF ENDPOINTS.
   80 CONTINUE
        CALL CLRSCRN
        PRINT *
        PRINT *,  ' WHICH METHOD DO YOU WISH TO USE TO DETERMINE THE'
        PRINT *,  ' DOUBLET DISTRIBUTION ENDPOINTS? '
        PRINT *,  '   1) PROGRAM INTERVAL HALVING SUBROUTINE TO ITERATE.'
        PRINT *,  '   2) MANUAL ITERATION BY THE USER.'
        PRINT *,  '   3) RETURN TO START'
        PRINT *,  '   4) EXIT PROGRAM'
        PRINT *,  ' ENTER 1,2,3 OR 4'
        PRINT *,  '  '
 24     READ (5,*) NMETH
        IF (NMETH .LT. 1 .OR. NMETH .GT. 4) THEN
```

```
            PRINT * , ' '
            PRINT *, ' INVALID ENTRY. ENTER A NUMBER BETWEEN'
            PRINT *, ' ONE(1) AND FOUR(4) INCLUSIVE.'
            GO TO 24
         END IF
         GO TO (120,100,5,999) NMETH
C
C   MANUALLY DETERMINE ENDPOINTS OF SOURCE DISTRIBUTION XS, XF
C
 100     CONTINUE
         CALL CLRSCRN
         PRINT *
         PRINT *,  '      ROUTINE FOR MANUAL DETERMINATION OF ENDPOINTS'
         PRINT *
         PRINT *,  '     ----------------------------------------------'
         PRINT *
         PRINT *,  ' ENTER THE DOUBLET DISTRIBUTION STARTING POINT, XS.'
         PRINT *,  ' (XS SHOULD BE APPROXIMATELY ONE HALF OF'
         PRINT *,  ' THE NONDIMENSIONAL LEADING EDGE RADIUS.)'
         READ (5,*) XS
         PRINT *
         PRINT *,  ' ENTER THE DOUBLET DISTRIBUTION ENDING POINT, XF.'
         PRINT *,  ' (XF SHOULD BE APPROXIMATELY ONE MINUS HALF'
         PRINT *,  ' OF THE NONDIMENSIONAL TRAILING EDGE RADIUS.)'
         READ (5,*) XF
         PRINT *
         PRINT *
         CALL FINDM (T,M,N,XS,XF)
         CALL PRESS(0.0,U0,CP0)
         CALL PRESS(1.0,U1,CP1)
         GO TO 150
C
  120    CONTINUE
         CALL CLRSCRN
         PRINT *
         PRINT *,  '      INTERVAL HALVING ROUTINE FOR DETERMINATION OF'
         PRINT *,  '             DOUBLET DISTRIBUTION ENDPOINTS'
         PRINT *
         PRINT *,  '     ----------------------------------------------'
         PRINT *
C          ENTER THE PARAMETERS REQUIRED BY THE INTERVAL HALVING METHOD
C          WHICH IS USED TO OBTAIN THE PROPER LOCATIONS FOR XS AND XF.
         PRINT *, ' ENTER THE INTEGER EXPONENT FOR THE X TOLERANCE, NXTOL.'
         PRINT *, '   EXAMPLE:  A VALUE OF 4, GIVES A TOLERANCE OF 0.0001.'
         READ (5,*) NXTOL
         PRINT *
         PRINT *, ' ENTER THE INTEGER EXPONENT FOR THE FUNCTION ',
        &          'TOLERANCE, NFTOL.'
         PRINT *, ' (SAME IDEA AS NXTOL; 5 YIELDS FTOL = 0.00001).'
         READ (5,*) NFTOL
         PRINT *
         PRINT *, ' ENTER THE MAXIMUM NUMBER OF ITERATIONS, MAXIT, TO '
         PRINT *, ' LOCATE XS AND XF. (FOR NFTOL = 6, SUGGEST 35-40) '
         READ (5,*) MAXIT
         PRINT *
         PRINT *, ' ENTER THE OUTPUT PARAMETER, IOUT.'
```

```
      PRINT *, '      IOUT = 0 TO SUPPRESS ALL ITERATION RELATED OUTPUT'
      PRINT *, '             1 TO OUTPUT FINAL RESULTS ONLY'
      PRINT *, '             2 TO OUTPUT DETAILS FOR EACH ITERATION'
      READ (5,*) IOUT
      CALL INTHV (NXTOL,NFTOL,NTYPE,MAXIT,IOUT,U0,U1)
C  RUN THROUGH PROCESS AGAIN WITH FINAL VALUES OBTAINED BY ITERATION
      CALL FINDM (T,M,N,XS,XF)
      CALL PRESS(0.0,U0,CP0)
      CALL PRESS(1.0,U1,CP1)
C
  150 PRINT *,  ' U AT X = 0 =',U0,'     XS =',XS
      PRINT *,  ' U AT X = 1 =',U1,'     XF =',XF
      PRINT *
      PRINT *,  ' THESE VALUES FOR U SHOULD BE NEAR ZERO.'
      PRINT *,  ' DO YOU ACCEPT THESE RESULTS (Y/N)'
      READ 1000, IANS
      IF (IANS .EQ. 'N') THEN
         PRINT *, 'CORRECTION LINE NO.1'
         GO TO (120,100) NMETH
      ELSE
         GO TO 152
      END IF
C
C              OUTPUT RESULTS
C
 152  PRINT 1010
      WRITE (11,1012)
      M(N+1)  = 0.0
      DO 200  I = 1,N+1
      MPLOT = REAL(M(I)*3.1415926585)
      PRINT 1040, T(I),MPLOT
 200  WRITE (11,1040) T(I),MPLOT
      CLOSE (UNIT=11)
      PRINT 1020
      WRITE (12,1020)
      IF (NTYPE .LE. 2)THEN
         DO 210  I = 1,N
         XX      = .5*(T(I) + T(I+1))
         YY      = Y(XX)
         PRINT 1040, XX,YY
         WRITE (15,1040) XX,YY
 210     WRITE (12,1040) XX,YY
         XX = 1.0
         YY = 0.0
         WRITE (15,1040) XX,YY
      ENDIF
      IF (NTYPE .EQ. 3) THEN
         DO 211 I = 1,DATPO+2
         XX      = COORX(I)
         YY      = COORY(I)
         PRINT 1040, XX,YY
         WRITE (15,1040) XX,YY
 211     WRITE (12,1040) XX,YY
      END IF
      CLOSE (UNIT=12)
      CLOSE (UNIT=15)
      PRINT 1030
 212  READ (5,*)   NPRINT
      IF (NPRINT .LT. 2) THEN
          PRINT *, '  YOU MUST ENTER A MINIMUM OF 2. PLEASE REENTER.'
          GO TO 212
      END IF
      WRITE (13,1032)
      DO 220  I = 1,NPRINT
      XX      = (I-1)/FLOAT(NPRINT-1)
      CALL PRESS(XX,U,CP)
      PRINT 1040, XX,CP
      WRITE (14,1040) XX,CP
 220  WRITE (13,1040) XX,CP
      CLOSE (UNIT = 13)
      CLOSE (UNIT=14)
C  CALL LIBRARY ROUTINE TO CLEAR THE SCREEN, THEN PRINT HEADER
      CALL CLRSCRN
      PRINT *
      PRINT *, ' PROGRAM DUBLET RESULTS HAVE BEEN WRITTEN TO FILES:'
      PRINT *
      PRINT *, ' DUBLET.DAT  :  DOUBLET STRENGTH DISTRIBUTION'
      PRINT *, ' SHAPE.DAT   :  BODY SURFACE COORDINATES'
      PRINT *, ' PRESSURE.DAT:  SURFACE PRESSURE DISTRIBUTION'
      PRINT *
      PRINT *
      PRINT *, 'WOULD YOU LIKE TO PRINT THE RESULTS (Y/N)?'
      PRINT *
      READ 1002, PRINT
      IF (PRINT.EQ.'Y'.OR.PRINT.EQ.'y')THEN
      PRINT *
      PRINT *, 'WHICH OF THE FOLLOWING FILES DO YOU WANT?'
      PRINT *
      PRINT *, '             1)  DUBLET.DAT'
      PRINT *, '             2)  PRESSURE.DAT'
      PRINT *, '             3)  SHAPE.DAT'
      PRINT *, '   OR        4)  ALL THREE FILES'
      PRINT *
      PRINT *, 'INPUT OPTION NO.(1,2,3, OR 4)'
 12    READ 1006, PRINTOPT
      IF (PRINTOPT .LT. 1 .OR. PRINTOPT .GT. 4) THEN
         PRINT *, 'INVALID ENTRY, ENTER INTEGER BETWEEN'
         PRINT *, 'ONE(1) AND FOUR(4).'
         PRINT *, ' '
         GO TO 12
      ENDIF
      ENDIF
      IF (PRINTOPT .EQ. 1) THEN
         CALL LIB$SPAWN('PRINT DUBLET.DAT')
      ENDIF
      IF (PRINTOPT .EQ. 2) THEN
         CALL LIB$SPAWN('PRINT PRESSURE.DAT')
      ENDIF
      IF (PRINTOPT .EQ. 3) THEN
         CALL LIB$SPAWN('PRINT SHAPE.DAT')
      ENDIF
      IF (PRINTOPT .EQ. 4) THEN
```

```
           CALL LIB$SPAWN('PRINT DUBLET.DAT,PRESSURE.DAT,SHAPE.DAT')
        ENDIF
        PRINT *
        PRINT *
        PRINT *, 'WOULD YOU LIKE TO GRAPH THE RESULTS (Y/N)?'
        PRINT *
        READ 1002, GRAPH
        IF (GRAPH.EQ.'Y'.OR.GRAPH.EQ.'y')THEN
 46     PRINT *
        PRINT *, 'WHICH OF THE FOLLOWING DATA FILES'
        PRINT *, 'DO YOU WANT TO GRAPH?'
        PRINT *
        PRINT *, '           1)  DUBLET.DAT'
        PRINT *, '           2)  PRESSURE.DAT'
        PRINT *, '           3)  SHAPE.DAT'
        PRINT *, '           4)  NONE'
        PRINT *
        PRINT *, 'INPUT OPTION NO.(1,2,3 OR 4)'
 616    READ 1006, GRAPHOPT
        IF (GRAPHOPT .LT. 1 .OR. GRAPHOPT .GT. 4) THEN
           PRINT *, 'INVALID ENTRY, ENTER INTEGER BETWEEN'
           PRINT *, 'ONE(1) AND FOUR(4).'
           PRINT *, ' '
           GO TO 616
        ENDIF
        IF (GRAPHOPT .EQ. 1) THEN
         CALL GRAPH1(NTYPE,XMAXY,TAU)
C      GET A HARDCOPY OF THIS GRAPHIC
         CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
       +SIZE=A P1.UIS')
        CALL LIB$SPAWN('CONTINUE')
        PRINT *, ' '
        PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
        PRINT *, ' '
        READ 1002, PLOT1
        IF (PLOT1.EQ.'Y'.OR.PLOT1.EQ.'y')THEN
          CALL LIB$SPAWN('PRINT P1.REN')
        ENDIF
        GO TO 46
        ENDIF
        IF (GRAPHOPT .EQ. 2) THEN
         CALL GRAPH2(NTYPE,XMAXY,NPRINT,TAU,N)
         CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
       +SIZE=A P2.UIS')
        PRINT *, ' '
        CALL LIB$SPAWN('CONTINUE')
        PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
        PRINT *, ' '
        READ 1002, PLOT2
        IF (PLOT2.EQ.'Y'.OR.PLOT2.EQ.'y')THEN
          CALL LIB$SPAWN('PRINT P2.REN')
        ENDIF
        GO TO 46
        ENDIF
        IF (GRAPHOPT .EQ. 3) THEN
         CALL GRAPH3(NTYPE,XMAXY,N,TAU,DATPO)
        CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
     +SIZE=A P3.UIS')
      PRINT *, ' '
      CALL LIB$SPAWN('CONTINUE')
      PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
      PRINT *, ' '
      READ 1002, PLOT3
      IF (PLOT3.EQ.'Y'.OR.PLOT3.EQ.'y')THEN
        CALL LIB$SPAWN('PRINT P3.REN')
      ENDIF
      GO TO 46
      ENDIF
      IF (GRAPHOPT .EQ. 4) THEN
        GO TO 64
      ENDIF
      ENDIF
C         OPTION TO MAKE ANOTHER RUN
 64     PRINT *
      PRINT *, ' DO YOU WISH TO:    '
      PRINT *, '       1) MAKE ANOTHER RUN OR'
      PRINT *, '       2) END THIS SESSION'
      PRINT *, ' ENTER 1 OR 2.'
      PRINT *
      CALL QUERY (NANS)
      CALL CLRSCRN
      IF (NANS .EQ. 1)  GO TO 10
 999  STOP
 1000 FORMAT(A1)
 1002 FORMAT(A1)
 1006 FORMAT(I1)
 1010 FORMAT(/,' DOUBLET STRENGTH DISTRIBUTION',/,
     +        ' M = M(I) FOR T(I) .LT. T .LT. T(I+1)',//,
     +        5X,'T(I)',5X,'M(I)/2',/)
 1012 FORMAT(/,9X,' DOUBLET STRENGTH DISTRIBUTION',//,
     +        14X,'T(I)',5X,'M(I)/2',/)
 1020 FORMAT(//,9X,' BODY SHAPE - UPPER SURFACE',//,15X,'X',9X,'Y',/)
 1030 FORMAT(//,' BODY SURFACE PRESSURE DISTRIBUTION',//,
     +        6X,'X',8X,'CP',//,' INPUT NUMBER OF PRESSURE COEFFICIENT',
     +        ' OUTPUT POINTS')
 1032 FORMAT(//,9X,' BODY SURFACE PRESSURE DISTRIBUTION',//,
     +        16X,'X',8X,'CP',//)
 1040 FORMAT(9X,2F10.4)
      END

      SUBROUTINE CLRSCRN
C
C  LIBRARY ROUTINE TO CLEAR THE SCREEN.
C
      ISTAT = LIB$ERASE_PAGE (1,1)
      RETURN
      END
C
      SUBROUTINE QUERY(NANS)
C
C  ROUTINE TO TRAP ERRORS CAUSED BY IMPROPER RESPONSES TO QUESTIONS.
C  THE COMPUTER GENERATES AND ERROR WHEN A CHARACTER IS SUPPLIED TO
```

```
C  A QUESTION EXPECTING AN INTEGER OR REAL VALUE.
C
      NQTEST=0
    1 CONTINUE
      IF (NQTEST .GT. 0) THEN
         PRINT *, '  CHARACTER VALUES ARE NOT VALID.'
         PRINT *, '  PLEASE ENTER AN INTEGER VALUE.'
      END IF
      NQTEST = NQTEST + 1
      READ (5,*,ERR=1)NANS
      RETURN
      END

      SUBROUTINE FINDM (T,M,N,XS,XF)
C
C             FIND DOUBLET STRENGTH TO MEET
C             FLOW TANGENCY CONDITION
C
      REAL*4 T(100),M(100),XS,XF
      INTEGER N,R
      COMMON /COF/ A(101,111),NEQNS
      PI       = 3.1415926585
      NP       = N + 1
      DO 100 I = 1,NP
C     COSINE SPACING SCHEME FROM XS TO XF
      FRACT    = .5*(1. - COS(PI*(I-1)/FLOAT(N)))
  100 T(I)     = XS + (XF - XS)*FRACT
C
C             SET UP LINEAR SYSTEM OF EQUATIONS
C
         DO 210  I = 1,N
            XI       = .5*(T(I) + T(I+1))
            YI       = Y(XI)
            FAC1     = ATAN2(T(1) - XI,YI)
            DO 200  J = 1,N
               FAC2     = ATAN2(T(J+1) - XI,YI)
               A(I,J)   = (FAC2 - FAC1)/YI
               FAC1     = FAC2
  200       CONTINUE
            A(I,NP) = 1.0
  210    CONTINUE
C
C             SOLVE FOR DOUBLET STRENGTH
C
      NEQNS    = N
      CALL GAUSS(1)
      DO 300  I = 1,N
  300 M(I)     = A(I,NP)
      RETURN
      END

      SUBROUTINE  FIX(VALMAX,VALMIN)
C  ARRAY = THE ARRAY WHICH IS BEING SORTED INTO ASCENDING ORDER
C  NUMBER= THE NUMBER OF ELEMENTS IN THE ARRAY TO BE SORTED
C  VALMAX= LARGEST VALUE IN THE ARRAY
C  VALMIN= SMALLEST VALUE IN THE ARRAY
```

```
      REAL VALMAX,VALMIN
      INTEGER NUMBER
      LOGICAL SORTED
      COMMON /JACKEL/YPLOT,NP
      DIMENSION ARRAY(100),YPLOT(100)
      SORTED = .FALSE.
      NUMBER = NP
      DO 20 I = 1,NUMBER
        ARRAY(I) = YPLOT(I)
   20 CONTINUE
   30 IF (.NOT.SORTED) THEN
         SORTED = .TRUE.
         DO 40 I = 1,NUMBER - 1
           IF(ARRAY(I).GT.ARRAY(I+1))THEN
             VALUE = ARRAY(I)
             ARRAY(I) = ARRAY(I+1)
             ARRAY(I+1) = VALUE
             SORTED = .FALSE.
           ENDIF
   40    CONTINUE
         GO TO 30
      ENDIF
      VALMAX = ARRAY(NUMBER)
      VALMIN = ARRAY(1)
*  THE FOLLOWING FILE IS CREATED TO CHECK THE VALIDITY OF THIS ROUTINE
      OPEN (UNIT=26,FILE='ARRAY3.DAT',STATUS='NEW')
      DO 45 I = 1,NUMBER
         WRITE (17,55)ARRAY(I)
   45 CONTINUE
      WRITE (17,65)VALMAX,VALMIN,NUMBER
   55 FORMAT(1X,E11.4)
   65 FORMAT(/,1X,'VALMAX = ',F6.4,/,'VALMIN = ',E11.4,/,'NUMBER = ',I3)
      CLOSE (UNIT=26)
      RETURN
      END

      SUBROUTINE GAUSS (NRHS)
C
C        SOLUTION OF LINEAR ALGEBRAIC SYSTEM BY
C        GAUSS ELIMINATION WITH PARTIAL PIVOTING
C
C             A        = COEFFICIENT MATRIX
C             NEQNS      = NUMBER OF EQUATIONS
C             NRHS       = NUMBER OF RIGHT HAND SIDES
C
C             RIGHT-HAND SIDES AND SOLUTIONS STORED IN
C             COLUMNS NEQNS+1 THRU NEQNS+NRHS OF °A
C
      COMMON DX,DY,AR,PI
      COMMON /COF/ A(350,351),NEQNS
      NP       = NEQNS + 1
      NTOT     = NEQNS + NRHS
C
C             GAUSS REDUCTION
C
```

```
      DO 150  I = 2,NEQNS
C
C            --  SEARCH FOR LARGEST ENTRY IN (I-1)TH COLUMN
C                ON OR BELOW MAIN DIAGONAL
C
        IM      = I - 1
        IMAX    = IM
        AMAX    = ABS(A(IM,IM))
        DO 110  J = I,NEQNS
          IF (AMAX .GE. ABS(A(J,IM))) GO TO 110
          IMAX    = J
          AMAX    = ABS(A(J,IM))
 110    CONTINUE
C
C            --   SWITCH (I-1)TH AND IMAXTH EQUATIONS
C
        IF (IMAX .NE. IM)   GO TO 140
        DO 130  J = IM,NTOT
          TEMP    = A(IM,J)
          A(IM,J) = A(IMAX,J)
          A(IMAX,J) = TEMP
 130    CONTINUE
C
C              ELIMINATE (I-1)TH UNKNOWN FROM
C              ITH THRU (NEQNS)TH EQUATIONS
C
 140  DO 150  J = I,NEQNS
              R = A(J,IM)/A(IM,IM)
        DO 150  K = I,NTOT
 150       A(J,K) = A(J,K) - R*A(IM,K)
C
C              BACK SUBSTITUTION
C
      DO 220  K = NP,NTOT
        A(NEQNS,K) = A(NEQNS,K)/A(NEQNS,NEQNS)
        DO 210  L = 2,NEQNS
          I       = NEQNS + 1 - L
          IP      = I + 1
          DO 200  J = IP,NEQNS
 200        A(I,K)  = A(I,K) - A(I,J)*A(J,K)
 210.       A(I,K)  = A(I,K)/A(I,I)
 220  CONTINUE
      RETURN
      END

      SUBROUTINE GRAPH1(NTYPE,XMAXY,TAU)
C
C    DEFINE IPACK ARRAY FOR LEGEND
      INTEGER*4 IPACK(35)
      REAL*4 T(100),M(100),XS,XF,TAU,XMAXY,MIN,MAX
      INTEGER N,R,NTYPE,NP
      COMMON /MAIN/T,M,N,XS,XF
      COMMON /JACKEL/YPLOT,NP
      CHARACTER*40 L1
      DIMENSION YPLOT(100)
C    DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
```

```
      L1 = 'DOUBLET STRENGTH$'
C    INITIALIZE THE GRAPHICS SYSTEM
      CALL INIT
C    LABEL X AND Y AXES USING SELF COUNTING STRINGS
      CALL XNAME('X',1)
      CALL YNAME('STRENGTH',8)
C    DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
      CALL AREA2D(6.0,8.0)
C    DEFINE HEADING LABEL
      CALL HEADIN('DOUBLET STRENGTH DISTRIBUTION$',-100,2.,1)
C    PLOT ADDITIONAL TICK MARKS
      CALL XTICKS(1)
      CALL YTICKS(1)
C    PACK LEGEND LABELS INTO ARRAY IPACK
      CALL LINES(L1,IPACK,1)
C     COSINE SPACING SCHEME FROM XS TO XF
      PI      = 3.1415926585
      NP      = N + 1
      DO 100 I = 1,NP
      FRACT   = .5*(1. - COS(PI*(I-1)/FLOAT(N)))
 100  T(I)    = XS + (XF - XS)*FRACT
C    CREATE THE RESPECTIVE VALUES FOR YPLOT
      DO 207 I = 1,N+1
      YPLOT(I) = REAL(M(I)*3.1415926585)
  207 CONTINUE
      CALL FIX(MAX,MIN)
C    SET UP AXIS
      CALL GRAF(0.,.2,1.,(MIN-.1),.05,(MAX+.2))
C    FRAME THE SUBPLOT AREA
      CALL FRAME
C    PLOT DUBLET STRENGTH DATA WITH A THICK LINE AND MARKER 15
      CALL MARKER(15)
      CALL THKCRV(.04)
      CALL CURVE(T,YPLOT,NP,1)
C    PLOT MESSAGES
      IF (NTYPE.EQ.1) THEN
        CALL MESSAG('ELLIPTICAL AIRFOIL DOUBLET DISTRIBUTION$',100,
     + .5,6.)
        CALL MESSAG('THICKNESS RATIO (TAU) = $',100,.5,5.5)
        CALL REALNO(TAU,2,4.,5.5)
      CALL MESSAG('NUMBER OF INTERVALS USED = $',100,.5,5.)
      CALL INTNO(N,'ABUT','ABUT')
      ENDIF
      IF (NTYPE.EQ.2) THEN
        CALL MESSAG('SYMMETRIC AIRFOIL DOUBLET DISTRIBUTION$',100,
     + .75,2.5)
        CALL MESSAG('THICKNESS RATIO (TAU) = $',100,.75,2.)
        CALL REALNO(TAU,2,4.,2.)
        CALL MESSAG('MAXIMUM THICKNESS AT X = $',100,.75,1.5)
        CALL REALNO(XMAXY,2,4.1,1.5)
        CALL MESSAG('NUMBER OF INTERVALS USED = $',100,.75,1.)
        CALL INTNO(N,'ABUT','ABUT')
      ENDIF
      IF (NTYPE.EQ.3) THEN
        CALL MESSAG('ARBITRARY SHAPE DOUBLET DISTRIBUTION$'
     +  ,100,.75,1.5)
```

```
          CALL MESSAG('NUMBER OF INTERVALS USED = $',100,.75,1.)
          CALL INTNO(N,'ABUT','ABUT')
        ENDIF
C    PLOT LEGEND
        CALL MYLEGN('DOUBLET STRENGTH$',100)
C     PLOT LEGEND
        CALL LEGEND(IPACK,1,3.0,7.0)
C     END PLOT
        CALL ENDPL(0)
C     CREATE GRAPHICS METAFILE P1.UIS
        CALL METAFL(1)
C     TERMINATE PLOT AT END OF PLOTTING SESSION
        CALL DONEPL
        RETURN
        END

       SUBROUTINE GRAPH2(NTYPE,XMAXY,NPRINT,TAU,N)
C
C     DEFINE IPACK ARRAY FOR LEGEND
       INTEGER*4 IPACK(35)
       INTEGER NUM,NPRINT,NTYPE,N
       REAL XX(100),CP(100),MAX,MIN,TAU,XMAXY
       CHARACTER*40 L1
       COMMON /ABLE/CP,NUM
C     READ ELEMENTS OF UNIT 14 INTO ARRAYS TO PLOT
        OPEN(UNIT=14,FILE='PRESS.DAT',STATUS='OLD')
        DO 25 I = 1,NPRINT
        READ (14,*)XX(I),CP(I)
  25    CONTINUE
        NUM = NPRINT
        CLOSE(UNIT=14)
        CALL SCALER2(MAX,MIN)
C     DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
        L1 = 'CP DISTRIBUTION$'
C     INITIALIZE THE GRAPHICS SYSTEM
        CALL INIT
C     LABEL X AND Y AXES USING SELF COUNTING STRINGS
        CALL XNAME('X$',100)
        CALL YNAME('CP$',100)
C     DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
        CALL AREA2D(6.0,8.0)
C     DEFINE HEADING LABEL
        CALL HEADIN('CP DISTRIBUTION$',-100,2.,1)
C     PLOT ADDITIONAL TICK MARKS
        CALL XTICKS(1)
        CALL YTICKS(1)
C     PACK LEGEND LABELS INTO ARRAY IPACK
        CALL LINES(L1,IPACK,1)
C     SET UP AXIS
        CALL GRAF(0.0,0.2,1.0,(MIN-.1),((MAX-MIN)/5.),(MAX+.1))
C     FRAME THE SUBPLOT AREA
        CALL FRAME
C     PLOT PRESSURE DISTRIBUTION DATA WITH A THICK LINE AND MARKER 15
        CALL MARKER(15)
        CALL THKCRV(.04)
        CALL CURVE(XX,CP,NUM,1)
C     PLOT MESSAGES
        IF (NTYPE.EQ.1) THEN
          CALL MESSAG('ELLIPTICAL AIRFOIL CP DISTRIBUTION$',100,
     + .75,4.)
          CALL MESSAG('THICKNESS RATIO (TAU) = $',100,.75,3.5)
          CALL REALNO(TAU,2,4.,3.5)
          CALL MESSAG('NUMBER OF INTERVALS USED = $',100,.75,3.0)
          CALL INTNO(N,'ABUT','ABUT')
        ENDIF
        IF (NTYPE.EQ.2) THEN
          CALL MESSAG('SYMMETRIC AIRFOIL CP DISTRIBUTION$',100,
     + .75,6.0)
          CALL MESSAG('THICKNESS RATIO (TAU) = $',100,.75,5.5)
          CALL REALNO(TAU,2,4.1,5.5)
          CALL MESSAG('MAXIMUM THICKNESS AT X = $',100,.75,5.)
          CALL REALNO(XMAXY,2,4.1,5.)
          CALL MESSAG('NUMBER OF INTERVALS USED = $',100,.75,4.5)
          CALL INTNO(N,'ABUT','ABUT')
        ENDIF
        IF (NTYPE.EQ.3) THEN
          CALL MESSAG('ARBITRARY SHAPE CP DISTRIBUTION$'
     + ,100,.75,5.5)
          CALL MESSAG('NUMBER OF INTERVALS USED = $',100,.75,5.0)
          CALL INTNO(N,'ABUT','ABUT')
        ENDIF
C     CHANGE LEGEND NAME TO "CP DISTRIBUTION"
        CALL MYLEGN('CP DISTRIBUTION$',100)
C     PLOT LEGEND
        CALL LEGEND(IPACK,1,2.0,7.0)
C     END PLOT
        CALL ENDPL(0)
C     CREATE GRAPHICS METAFILE P2.UIS
        CALL METAFL(2)
C     TERMINATE PLOT AT END OF PLOTTING SESSION
        CALL DONEPL
        RETURN
        END

       SUBROUTINE GRAPH3(NTYPE,XMAXY,N,TAU,DATPO)
C
C     DEFINE IPACK ARRAY FOR LEGEND
       INTEGER*4 IPACK(35)
       INTEGER NUM,NTYPE,N,DATPO
       REAL XX(100),YY(100),MAX,MIN,TAU,XMAY
       CHARACTER*40 L1
       COMMON /JACK/YY,NUM
C     READ ELEMENTS OF UNIT 15 INTO ARRAYS TO PLOT
        OPEN(UNIT=15,FILE='SHAPEBODY.DAT',STATUS='OLD')
        IF (NTYPE .LE. 2) THEN
        XX(1) = 0.0
        YY(1) = 0.0
        DO 25 I = 2,N+2
           READ(15,*)XX(I),YY(I)
  25    CONTINUE
        XX(N+3) = 1.0
        YY(N+3) = 0.0
        NUM = N + 3
        ENDIF
        IF (NTYPE .EQ. 3) THEN
        DO 35 I = 1,DATPO+2
           READ(15,*)XX(I),YY(I)
 35     CONTINUE
        NUM = DATPO +2
        ENDIF
        CLOSE(UNIT=15)
C     CALL SCALER TO FIND THE MAX AND MIN VALUES OF THE Y ORDINATE ARRAY
        CALL SCALER(MAX,MIN)
C     DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
        L1 = 'AIRFOIL SHAPE$'
C     INITIALIZE THE GRAPHICS SYSTEM
        CALL INIT
C     LABEL X AND Y AXES USING SELF COUNTING STRINGS
        CALL XNAME('X$',100)
        CALL YNAME('Y$',100)
C     DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
        CALL AREA2D(6.0,8.0)
C     DEFINE HEADING LABEL
        CALL HEADIN('AIRFOIL SHAPE$',-100,2.,1)
C     PLOT ADDITIONAL TICK MARKS
        CALL XTICKS(1)
        CALL YTICKS(1)
C     PACK LEGEND LABELS INTO ARRAY IPACK
        CALL LINES(L1,IPACK,1)
C     SET UP AXIS
        CALL GRAF(0.,.2,1.,0.,((MAX-MIN+.4)/5.),(MAX+.4))
C     FRAME THE SUBPLOT AREA
        CALL FRAME
C     PLOT PRESSURE DISTRIBUTION DATA WITH A THICK LINE AND MARKER 15
        CALL MARKER(15)
        CALL THKCRV(.04)
        CALL CURVE(XX,YY,NUM,1)
C     PLOT MESSAGES
        IF (NTYPE.EQ.1) THEN
          CALL MESSAG('ELLIPTICAL AIRFOIL SHAPE$',100,
     + 1.,5.)
          CALL MESSAG('THICKNESS RATIO (TAU) = $',100,1.,4.5)
          CALL REALNO(TAU,2,4.5,4.5)
          CALL MESSAG('NUMBER OF INTERVALS USED = $',100,1.,4.0)
          CALL INTNO(N,'ABUT','ABUT')
        ENDIF
        IF (NTYPE.EQ.2) THEN
          CALL MESSAG('SYMMETRIC AIRFOIL SHAPE$',100,
     + 1.,5.0)
          CALL MESSAG('THICKNESS RATIO (TAU) = $',100,1.,4.5)
          CALL REALNO(TAU,2,4.3,4.5)
          CALL MESSAG('MAXIMUM THICKNESS AT X = $',100,1.,4.)
          CALL REALNO(XMAXY,2,4.4,4.)
          CALL MESSAG('NUMBER OF INTERVALS USED = $',100,1.,3.5)
          CALL INTNO(N,'ABUT','ABUT')
        ENDIF
        IF (NTYPE.EQ.3) THEN
```

```
            CALL MESSAG('ARBITRARY SHAPE$',100,1.,4.5)
            CALL MESSAG('NUMBER OF INTERVALS USED = $',100,1.,4.)
            CALL INTNO(N,'ABUT','ABUT')
          ENDIF
C       CHANGE LEGEND NAME TO "UPPER SURFACE ONLY"
          CALL MYLEGN('UPPER SURFACE$',100)
C       PLOT LEGEND
          CALL LEGEND(IPACK,1,3.0,7.0)
C       END PLOT
          CALL ENDPL(0)
C       CREATE GRAPHICS METAFILE P3.UIS
          CALL METAFL(3)
C       TERMINATE PLOT AT END OF PLOTTING SESSION
          CALL DONEPL
          RETURN
          END

         SUBROUTINE INTHV (NXTOL,NFTOL,NTYPE,MAXIT,IOUT,U0,U1)
C
         COMMON /MAIN/T,M,N,XS,XF
         DIMENSION T(100),M(100)
C      SUBROUTINE TO FIND THE ROOTS OF f(x) = 0 USING THE
C      INTERVAL HALVING METHOD
C
C      IN THE PARAMETER LIST THE USER MUST PROVIDE:
C            NXTOL = EXPONENT FOR X TOLERANCE VALUE
C            NFTOL = EXPONENT FOR FUNCTION TOLERANCE VALUE
C            NTYPE = SHAPE TYPE; ELLIPTICAL OR AIRFOIL
C            MAXIT = MAXIMUM NUMBER OF ITERATIONS
C             IOUT = 0 TO SUPPRESS ALL OUTPUT (TO DEVICE IW)
C                    1 TO OUTPUT FINAL RESULTS ONLY
C                    2 TO OUTPUT DETAILS FOR EACH ITERATION
C      THE SUBROUTINE CALCULATES:
C         XPREV, X = TWO INITIAL GUESSES, GIVEN N
C      THE SUBROUTINE RETURNS:
C           XS, XF = CURRENT X VALUES WHEN TERMINATION OCCURRED
C           U0, U1 = CURRENT VELOCITY VALUES WHEN TERMINATION OCCURRED
C            IEXIT = 1, 2, 3, 4 OR 7 (SEE FORMAT STATEMENTS 1 - 4 & 7)
C
         IW = 5
         XTOL = 10.**(-NXTOL)
         FTOL = 10.**(-NFTOL)
C      CALCULATE INITIAL GUESS FOR XS AND XF, GIVEN N
         XS = 1. / FLOAT(N + 1)
         XSPREV = 10.**(-6)
         XF = 1. - XS
         XFPREV = 1. - XSPREV
C      SET X VALUES FOR LEADING AND TRAILING EDGES FOR SUBROUTINE PRESS
         XLE = 0.0
         XTE = 1.0
C
C      ITERATE TO DETERMINE THE PROPER LOCATION FOR XF
C
C      FIRST CHECK TO SEE THAT F(XF) & F(XFPREV) DIFFER IN SIGN
C      SO THAT THE METHOD WILL CONVERGE.
```

```
C
C    EVALUATE PREVIOUS X VALUE
       CALL FINDM (T,M,N,XS,XFPREV)
       CALL PRESS (XTE,U1,CP)
       YFPREV = U1
C    EVALUATE INITAL GUESS FOR X VALUE
       CALL FINDM (T,M,N,XS,XF)
       CALL PRESS (XTE,U1,CP)
       YF = U1
       IF (IOUT .GT. 1) WRITE (IW,5) XFPREV, YPREV, XF, YF
       IF (YFPREV*YF .GT. 0.0) THEN
          I = -2
          PRINT 201
          RETURN
       END IF
C
C    COMPUTE SEQUENCE OF POINTS CONVERGING TO THE ROOT
       IEXIT = 1
       DO 10 K=1, MAXIT
          XR = (XFPREV + XF)/2.0
C    FOR THE ELLIPTIC CASE XS AND XF WILL BE EQUIDISTANT FROM THE EDGES.
          IF (NTYPE .LT. 2) THEN
             XS = ABS (1. - XR)
          END IF
          CALL FINDM (T,M,N,XS,XR)
          CALL PRESS (XTE,U1,CP)
          Y = U1
C    CHECK ON STOPPING CRITERIA
C
          DELTAXF = XFPREV-XR
          XERR = ABS(XFPREV-XR)/2.0
          IF (IOUT .GT. 1) WRITE (IW,6) K,XR,Y,DELTAXF
          IF (Y .EQ. 0.0) IEXIT = 2
          IF (ABS(Y) .LE. FTOL) IEXIT = 3
          IF ( XERR .LE. XTOL) IEXIT = 7
          IF (IEXIT .GT. 1) GO TO 20
          IF (Y*YFPREV .GT. 0.0) THEN
             XFPREV = XR
             YFPREV = Y
          ELSE
             XF = XR
             YF = Y
          END IF
   10 CONTINUE
C    THE MAXIMUM ITERATIONS HAS BEEN EXCEEDED,WITHOUT FINDING A ROOT.
       IEXIT = 4
   20 IF (IOUT .EQ. 0) GO TO 30
       IF (IEXIT .EQ. 1 ) WRITE (IW, 1) XR
       IF (IEXIT .EQ. 2 ) WRITE (IW, 2) XR
       IF (IEXIT .EQ. 3 ) WRITE (IW, 3) XR, NUMSIG
       IF (IEXIT .EQ. 4 ) WRITE (IW, 4) MAXIT
   30 CONTINUE
C    FOR THE ELLIPTIC CASE XS ANND XF ARE DETERMINED, SO GO BACK.
C
       IF (NTYPE .LT. 2) THEN
          CALL FINDM (T,M,N,XS,XF)
```

```
            CALL PRESS (XLE,U0,CP)
            GO TO 90
         END IF
C    NOW DO THE SAME FOR XS
         PRINT *, '    VALUE OBTAINED FOR XF',XF
         PRINT *, '    -- WORKING ON XS.'
C    EVALUATE PREVIOUS X VALUE
         CALL FINDM (T,M,N,XSPREV,XF)
         CALL PRESS (XLE,U0,CP)
         YSPREV = U0
C    EVALUATE INITAL GUESS FOR X VALUE
         CALL FINDM (T,M,N,XS,XF)
         CALL PRESS (XLE,U0,CP)
         YS = U0
         IF (IOUT .GT. 1) WRITE (IW,5) XSPREV, YSPREV, XS, YS
         IF (YSPREV*YS .GT. 0.0) THEN
            I = -2
            PRINT 201
            RETURN
         END IF
C
C    COMPUTE SEQUENCE OF POINTS CONVERGING TO THE ROOT
         IEXIT = 1
         DO 40 K=1, MAXIT
              XR = (XSPREV + XS)/2.0
              CALL FINDM (T,M,N,XR,XF)
              CALL PRESS (XLE,U0,CP)
              Y = U0
C    CHECK ON STOPPING CRITERIA
C
              DELTAXS = XSPREV-XR
              XERR = ABS(XSPREV-XR)/2.0
              IF (IOUT .GT. 1) WRITE (IW,6) K,XR,Y,DELTAXS
              IF (Y .EQ. 0.0) IEXIT = 2
              IF (ABS(Y) .LE. FTOL) IEXIT = 3
              IF ( XERR .LE. XTOL) IEXIT = 7
              IF (IEXIT .GT. 1) GO TO 50
              IF (Y*YSPREV .GT. 0.0) THEN
                 XSPREV = XR
                 YSPREV = Y
              ELSE
                 XS = XR
                 YS = Y
              END IF
   40 CONTINUE
C    THE MAXIMUM ITERATIONS HAS BEEN EXCEEDED,WITHOUT FINDING A ROOT.
         IEXIT = 4
   50 IF (IOUT .EQ. 0) RETURN
         IF (IEXIT .EQ. 1 ) WRITE (IW, 1) XR
         IF (IEXIT .EQ. 2 ) WRITE (IW, 2) XR
         IF (IEXIT .EQ. 3 ) WRITE (IW, 3) XR, NUMSIG
         IF (IEXIT .EQ. 4 ) WRITE (IW, 4) MAXIT
         IF (IEXIT .EQ. 7 ) WRITE (IW, 7) XR, XTOL
   90 RETURN
C***********************************************************************
C
```

```
C
C   THIS SHOULD RETURN WITH U0 NEAR ZERO AND A GOOD VALUE OF XS.
    1 FORMAT('OSLOPE = 0 WHEN X =',G12.7,'.  ITERATION DISCONTINUED.')
    2 FORMAT('OCOMPUTED F( ',G12.7,') IS 0.  ITERATION DISCONTINUED.')
    3 FORMAT('OROOT:    ',G12.7,'. APPEARS TO BE ACCURATE TO ',I1,'S.')
    4 FORMAT('ODESIRED ACCURACY IS NOT EVIDENT IN ',I3,' ITERATIONS.')
    5 FORMAT('OHALVING METHOD:  X¢-1!, X¢0! ARE INITIAL GUESSES.',/,
     &        '0 k',4X,'X = Xk',7X,'Y = F(X)',7X,'X-XPREV',/,
     &        ' -1   ', G12.7, E12.5, /,'  0   ', G12.7, E12.5)
    6 FORMAT(I3, 3X, G12.7, E12.5, E15.5)
    7 FORMAT('OX LOCATION: ',G12.7,' IS WITHIN X TOLERANCE OF ',E12.5)
  201 FORMAT('OFUNCTION HAS THE SAME SIGN AT BOTH INITIAL POSITIONS.'
     &       ,/,'OTHE BUILT-IN ITERATION SCHEME WILL NOT WORK, THEREFORE'
     &       ,/,'OYOU MUST SELECT THE ENDPOINTS MANUALLY.')
      END

      SUBROUTINE PRESS(X,U,CP)
C
C             FIND PRESSURE COEFFICIENT CP AT (X,Y(X))
C
      COMMON /MAIN/T,M,N,XS,XF
      DIMENSION T(100),M(100)
      REAL     M
      YB       = Y(X)
      U        = 1.0
      V        = 0.0
      VF1      = 1./((T(1) - X)**2 + YB*YB)
      UF1      = (T(1) - X)*VF1
      DO 100   J = 1,N
      VF2      = 1./((T(J+1) - X)**2 + YB*YB)
      UF2      = (T(J+1) - X)*VF2
      U        = U + M(J)*(UF2 - UF1)
      V        = V - M(J)*YB*(VF2 - VF1)
      VF1      = VF2
 100  UF1      = UF2
      CP       = 1.0 - U*U - V*V
      RETURN
      END
C
      FUNCTION Y(X)
C
      COMMON /FCN/ AX,TAU,NTYPE
      COMMON /DATA/COORX(101),COORY(101)
      COMMON /PROB/DATPO
      DIMENSION FDP(101)
      REAL FIRST,LATER,UP,DOWN,ARC
      INTEGER N,DATPO
C
C        ORDINATE OF BODY CONTOUR
C
      IF (NTYPE .EQ. 1) THEN
C
C        PROVIDE BODY ORDINATES FOR AN ELLIPSE OF THICKNESS RATIO TAU
C        (CHORD HAS BEEN NONDIMENSIONALIZED, C=1.0)
C
C        TO REDUCE THE NUMBER OF VARIABLES PASSED IN THE FUNCITON
```

```
C        STATEMENT, THE DUMMY VARIABLE AX PASSES TAU FOR THE ELLIPSOID
C        CASE AND THE COEFFICIENT AX(TAU,XMAXY) FOR THE SYMMETRICAL
C        AIRFOIL-LIKE CASE.
C
      Y = TAU * SQRT(X*(1.-X))
         ELSEIF (NTYPE .EQ. 2) THEN
C
C        PROVIDE BODY ORDINATES FOR A SYMMETRIC AIRFOIL-LIKE SHAPE
C        (CHORD HAS BEEN NONDIMENSIONALIZED, C=1.0)
C
      Y = AX * SQRT(X)*(1-X)
         ELSE
C
C        PROVIDE BODY ORDINATES FOR AN ARBITRARY BODY.  TO DETERMINE
C        THESE POINTS A CUBIC SPLINE INTERPOLATION SUBROUTINE WAS ADDED
C        TO PROGRAM DUBLET.
C
      N = DATPO + 2
      XX = X
      CALL SPLINE(N,COORX,COORY,FDP)
      CALL SPEVAL(N,COORX,COORY,FDP,XX,F)
      Y = F
      ENDIF
      RETURN
      END

      SUBROUTINE  SCALER(VALMAX,VALMIN)
C
C  ARRAY = THE ARRAY WHICH IS BEING SORTED INTO ASCENDING ORDER
C  NUMBER= THE NUMBER OF ELEMENTS IN THE ARRAY TO BE SORTED
C  VALMAX= LARGEST VALUE IN THE ARRAY
C  VALMIN= SMALLEST VALUE IN THE ARRAY
      REAL VALMAX,VALMIN
      INTEGER NUMBER
      LOGICAL SORTED
      COMMON /JACK/YY,NUM
      DIMENSION ARRAY(100),YY(100)
      SORTED = .FALSE.
      NUMBER = NUM
      DO 20 I = 1,NUMBER
        ARRAY(I) = YY(I)
   20 CONTINUE
   30 IF (.NOT.SORTED) THEN
         SORTED = .TRUE.
         DO 40 I = 1,NUMBER - 1
           IF(ARRAY(I).GT.ARRAY(I+1))THEN
             VALUE = ARRAY(I)
             ARRAY(I) = ARRAY(I+1)
             ARRAY(I+1) = VALUE
             SORTED = .FALSE.
           ENDIF
   40    CONTINUE
         GO TO 30
      ENDIF
      VALMAX = ARRAY(NUMBER)
      VALMIN = ARRAY(1)
*  THE FOLLOWING FILE IS CREATED TO CHECK THE VALIDITY OF THIS ROUTINE
      OPEN (UNIT=16,FILE='ARRAY.DAT',STATUS='NEW')
      DO 45 I = 1,NUMBER
         WRITE (16,55)ARRAY(I)
   45 CONTINUE
      WRITE (16,65)VALMAX,VALMIN,NUMBER
   55 FORMAT(1X,E11.4)
   65 FORMAT(/,1X,'VALMAX = ',F6.4,/,'VALMIN = ',E11.4,/,'NUMBER = ',I3)
      CLOSE (UNIT=16)
      RETURN
      END

      SUBROUTINE  SCALER2(VALMAX,VALMIN)
C
C  ARRAY = THE ARRAY WHICH IS BEING SORTED INTO ASCENDING ORDER
C  NUMBER= THE NUMBER OF ELEMENTS IN THE ARRAY TO BE SORTED
C  VALMAX= LARGEST VALUE IN THE ARRAY
C  VALMIN= SMALLEST VALUE IN THE ARRAY
      REAL VALMAX,VALMIN
      INTEGER NUMBER
      LOGICAL SORTED
      COMMON /ABLE/CP,NUM
      DIMENSION ARRAY(100),CP(100)
      SORTED = .FALSE.
      NUMBER = NUM
      DO 20 I = 1,NUMBER
        ARRAY(I) = CP(I)
   20 CONTINUE
   30 IF (.NOT.SORTED) THEN
         SORTED = .TRUE.
         DO 40 I = 1,NUMBER - 1
           IF(ARRAY(I).GT.ARRAY(I+1))THEN
             VALUE = ARRAY(I)
             ARRAY(I) = ARRAY(I+1)
             ARRAY(I+1) = VALUE
             SORTED = .FALSE.
           ENDIF
   40    CONTINUE
         GO TO 30
      ENDIF
      VALMAX = ARRAY(NUMBER)
      VALMIN = ARRAY(1)
*  THE FOLLOWING FILE IS CREATED TO CHECK THE VALIDITY OF THIS ROUTINE
      OPEN (UNIT=17,FILE='ARRAY2.DAT',STATUS='NEW')
      DO 45 I = 1,NUMBER
         WRITE (17,55)ARRAY(I)
   45 CONTINUE
      WRITE (17,65)VALMAX,VALMIN,NUMBER
   55 FORMAT(1X,E11.4)
   65 FORMAT(/,1X,'VALMAX = ',F6.4,/,'VALMIN = ',E11.4,/,'NUMBER = ',I3)
      CLOSE (UNIT=17)
      RETURN
      END
      SUBROUTINE SPEVAL(N,COORX,COORY,FDP,XX,F)
C
C     THIS SUBROUTINE EVALUATES THE CUBIC SPLINE GIVEN
C     THE DERIVATIVES COMPUTED  BY SUBROUTINE SPLINE.
C     THE INPUT PARAMETERS N,X,Y,FDP HAVE THE SAME
C     MEANING AS IN SPLINE.
C     XX = VALUE OF INDEPENDENT VARIABLE FOR WHICH
C          AN INTERPOLATED VALUE IS REQUESTED
C     F  = THE INTERPOLATED RESULT
      DIMENSION COORX(101),COORY(101),FDP(101)
C     THE FIRST STEP IS TO FIND THE PROPER INTERVAL
      NM1 = N -1
      DO 1 I=1,NM1
      IF (XX.LE.COORX(I+1)) GO TO 10
    1 CONTINUE
C     NOW EVALUATE THE CUBIC
   10 DXM = XX - COORX(I)
      DXP = COORX(I+1) - XX
      DEL = COORX(I+1) - COORX(I)
      F = FDP(I)*DXP*(DXP*DXP/DEL - DEL)/6.
     1   +FDP(I+1)*DXM*(DXM*DXM/DEL - DEL)/6.
     2   +COORY(I)*DXP/DEL + COORY(I+1)*DXM/DEL
      RETURN
      END

      SUBROUTINE SPLINE (N,COORX,COORY,FDP)
C
C     THIS SUBROUTINE COMPUTES THE SECOND DERIVATIVES NEEDED
C     IN CUBIC SPLINE INTERPOLATION.  THE INPUT DATA ARE:
C     N     = NUMBER OF DATA POINTS
C     COORX = ARRAY CONTAINING THE VALUES OF THE INDEPENDENT VARIABLE
C             (ASSUMED TO BE ASCENDING ORDER)
C     COORY = ARRAY CONTAINING THE VALUES OF THE FUNCTION AT THE
C             DATA POINTS GIVEN IN THE COORX ARRAY
      DIMENSION COORX(101),COORY(101),A(101),B(101)
      DIMENSION C(101),R(101),FDP(101)
      ALAMDA = 1
      NM2 = N - 2
      NM1 = N - 1
      C(1) = COORX(2) - COORX(1)
      DO 1 I=2,NM1
      C(I) = COORX(I+1) - COORX(I)
      A(I) = C(I-1)
      B(I) = 2.*(A(I) + C(I))
      R(I) = 6.*((COORY(I+1)-COORY(I))/C(I)-(COORY(I)
     +      -COORY(I-1))/C(I-1))
    1 CONTINUE
      B(2) = B(2) + ALAMDA * C(1)
      B(NM1) = B(NM1) + ALAMDA * C(NM1)
      DO 2 I=3,NM1
      T = A(I)/B(I-1)
      B(I) = B(I) - T * C(I-1)
      R(I) = R(I) - T * R(I-1)
    2 CONTINUE
      FDP(NM1) = R(NM1)/B(NM1)
      DO 3 I=2,NM2
      NMI = N - I
      FDP(NMI) = (R(NMI) - C(NMI) * FDP(NMI+1))/B(NMI)
    3 CONTINUE
      FDP(1) = ALAMDA * FDP(2)
      FDP(N) = ALAMDA * FDP(NM1)
C     DESIRED DERIVATIVES HAVE NOW BEEN DETERMINED
C     RETURN TO MAIN PROGRAM
      RETURN
      END

      FUNCTION YREF(XNUM)
C
      COMMON /LEROY/NUMERAL
      COMMON /BRAVO/NUMPTS
      COMMON /CHARLIE/NO
      COMMON /FLAGGER/FIGURE
      DIMENSION FDP(101),XX(101),YY(101)
      DIMENSION XPOINT(101),YPOINT(101),XPOIN(101),YPOIN(101)
      NO = NUMPTS
C
C  READ IN THE CURRENT SHAPE OF THE AIRFOIL
C
       IF(FIGURE.EQ.2)NUMERAL=NUMERAL-2
       OPEN(UNIT=15,FILE='BODYSHAPE.DAT',STATUS='OLD')
       XX(1) = 0.0
       YY(1) = 0.0
       DO 30 I = 2,NUMERAL+1
         READ (15,*) XX(I),YY(I)
   30   CONTINUE
       XX(NUMERAL+2) = 1.
       YY(NUMERAL+2) = 0.
       CLOSE(UNIT=15)
C
C        PROVIDE BODY ORDINATES FOR AN ARBITRARY .  TO DETERMINE
C        THESE POINTS A CUBIC SPLINE INTERPOLATION SUBROUTINE WAS ADDED
C        TO PROGRAM NEW_PANEL.
C
C  THE AIRFOIL SHAPE IS BEING SPLIT INTO UPPER AND LOWER SURFACES AND
C  THEN FORMATTED TO BE USED WITH THE SPLINE/SPEVAL ROUTINES.
C
      NOB = INT(NUMPTS/2)+1
      DO I=1,INT(NUMPTS/2)+1
        DUMMY=XX(I)
        DUM  =YY(I)
        XPOINT(I)=DUMMY
        YPOINT(I)=DUM
      END DO
      DO I=INT(NUMPTS/2)+2,NUMPTS
        DUMM=XX(I)
        DU  =YY(I)
        XPOIN(I)=DUMM
        YPOIN(I)=DU
      END DO
        XPOIN(NUMPTS+1)=1.
        YPOIN(NUMPTS+1)=0.
        CALL SORTNUM(XPOINT,YPOINT,NOB)
        CALL SORTNUM(XPOIN,YPOIN,NOB-1)
C
C  UPPER SURFACE Y COORDINATE DETERMINATION
C
      IF (XNUM.GT.0.)THEN
        N = INT(NUMPTS/2)+1
        XPT = XNUM
        CALL SPLINE(N,XPOINT,YPOINT,FDP)
        CALL SPEVAL(N,XPOINT,YPOINT,FDP,XPT,F)
        YREF = F
      ENDIF
C
C  LOWER SURFACE Y COORDINATE DETERMINATION
C
      IF (XNUM.LT.0.)THEN
        N = INT(NUMPTS/2)
        XPT = XNUM
        CALL SPLINE(N,XPOIN,YPOIN,FDP)
        CALL SPEVAL(N,XPOIN,YPOIN,FDP,XPT,F)
        YREF = F
      ENDIF
      RETURN
      END
```

APPENDIX G. PROGRAM NEW_PANEL COMPUTER CODE

```
      PROGRAM NEW_PANEL
C
C *** MODIFIED FOR USE ON THE MICROVAX/2000 BY J.A. CAMPBELL (JUL 88)
C     UPDATES MADE BY C.M.MACALLISTER JAN-NOV 89 (CMM)
C ************************************************************************
C     PROGRAM NEW_PANEL
C
C        SMITH-HESS (DOUGLAS) PANEL METHOD
C        FOR SINGLE-ELEMENT LIFTING AIRFOIL
C        IN TWO-DIMENSIONAL INCOMPRESSIBLE FLOW
C
C     ORIGINAL IBM MAINFRAME PROGRAM WAS ADAPTED FROM JACK MORAN'S BOOK
C     'AN INTRODUCTION TO THEORETICAL AND COMPUTATIONAL AERODYNAMICS',
C     WILEY AND SONS, NEW YORK 1984.  THE LISTING IS FOUND ON PAGE 118.
C
C     PROGRAM FLEXIBILITY AND USER INTERFACE WAS REVISED FOR
C     PROFESSOR J.V. HEALEY BY JOHN CAMPBELL.   APRIL 1988.
C     ADDITIONAL PROGRAM UPDATES TO INCLUDE PRINTING ROUTINES,
C     PROCESSING CORRECTIONS, GRAPHICAL ANALYSIS, AND VISCOUS
C     INTERACTION ADDAPTATION WERE MADE BY CRAIG MACALLISTER
C     IN JAN-NOV 1989.  (CMM)
C
C     THE VISCOUS INTERACTION ADAPTATION WAS REALIZED USING A
C     FORTRAN PROGRAM DEVELOPED BY DR. T. CEBECI AND DR. H.
C     B. KELLER.  THE ORIGINAL VERSION OF THIS PROGRAM IS
C     CURRENTLY AVAILABLE FOR USE ON THE IBM MAINFRAME AT THE
C     NAVAL POSTGRADUATE SCHOOL, ACCOUNT 4632P.  IN ORDER TO
C     USE DR. CEBECI'S PROGRAM IT IS NECESSARY TO INPUT THE
C     POTENTIAL FLOW SOLUTION OVER A SECTION SHAPE.  IN PARTICU-
C     LAR, THE CP DISTRIBUTION OR THE VELOCITY DISTRIBUTION OVER
C     AS SURFACE IS REQUIRED.  SUCH INFORMATION IS OBTAINED QUITE
C     READILY THROUGH THE EXECUTION OF THE NEW_PANEL PROGRAM.  IN
C     FACT, THE CP DISTRIBUTION CREATED BY NEW_PANEL IS INTER-
C     ACTIVELY ADAPTED, SORTED AND INPUTTED TO THE CEBECI PROGRAM
C     UPON THE USER'S REQUEST.
C
C     THIS PROGRAM PROVIDES THE BODY COORDINATES AND THE SURFACE
C     PRESSURE DISTRIBUTION ABOUT A SINGLE ELEMENT LIFTING AIRFOIL
C     IN TWO-DIMENSIONAL FLOW.
C
C     ESTIMATED VALUES FOR LIFT COEFFICIENT AND THE MOMENT COEFFICIENT
C     ABOUT THE LEADING EDGE AND QUARTER CHORD ARE DETERMINED FROM THE
C     PRESSURE COEFFICIENTS OF EACH PANEL.
C
C     YOU MAY PROVIDE ACTUAL AIRFOIL SURFACE COORDINATE DATA VALUES OR
C     HAVE THE COMPUTER GENERATE AN APPROXIMATION FOR THE COORDINATES
C     OF A NACA XXXX OR 230XX AIRFOIL SECTION.
C
C     IF YOU DESIRE TO ENTER THE SURFACE COORDINATE VALUES, SEVERAL
C     OPTIONS ARE AVAILABLE.  YOU MAY ENTER THEM 1) FROM A DATA FILE,
C     2) FROM THE KEYBOARD OR 3) USING DATA STATEMENTS ALREADY ENTERED
C     AT THE END OF THE MAIN PROGRAM LISTING.
C
C     IF INPUTTING YOUR OWN DATA, REMEMBER TO START AT THE TRAILING EDGE
```

```
C     (X/C = 1.0), AND WORK TOWARDS THE LEADING EDGE, ENTERING THE LOWER
C     SIDE FIRST, FOLLOWED BY THE UPPER SURFACE.  DO NOT ENTER THE
C     TRAILING EDGE TWICE.  TRY TO ENTER A SUFFICIENT NUMBER OF POINTS
C     NEAR THE NOSE FOR GOOD RESOLUTION.
C
C *** NOTE:  TO SATISFY THE KUTTA CONDITION, X VALUES FOR POINTS
C            2 AND N MUST BE THE SAME. THIS ENSURES THAT THE LAST
C            PANELS, UPPER AND LOWER, ARE OF EQUAL SIZE.
C
C            CD IS JUST AN INDICATOR OF NUMERICAL ACCURACY OF THIS
C            PROGRAM. VALUE OF CD SHOULD BE NEAR ZERO.
C
C            IF USING DATA STMTS OR AN INPUT FILE, REMEMBER THE NUMBER
C            OF DATA VALUES AS YOU WILL BE ASKED FOR THIS BY THE PROGRAM.
C
C            USE OF THE DATA STATEMENTS REQUIRES THAT PROGRAM BE
C            MODIFIED IN ADVANCE BY MOVING THEM TO THE CORRECT LOCATION.
C
C ***********************************************************************
      INTEGER   NANS,FLAG,FIGURE
      REAL LIFTA,MOMENTA,MENTA
      DIMENSION XX(101),YCORD(101),YCOORD(101),DLS(101),THT(101)
      DIMENSION  ANGLE(13),CLA(13),CMA(13),CMB(13),YY(101),XREF(101)
      DIMENSION YDAT(101)
C
C *** NOTE:  IF YOU CHANGE SIZE OF X AND Y, CHANGE N BELOW ALSO|     ***
C
      CHARACTER*1  PRINT,GRAPH,PLOT1,PLOT2,PLOT3,PLOT4,PLOT5
      CHARACTER*1 VISCOUS,PRINTER
      INTEGER PRINTOPT,GRAPHOPT,THICKOPT,VISOPT
      DATA X, Y /101*0.,101*0./
      DATA ANGLE/-8.,-6.,-4.,-2.,0.,2.,4.,6.,8.,10.,12.,14.,16./
      COMMON /EXTRA/LIFTA,MOMENTA,MENTA
      COMMON /DATA/X(101),Y(101)
      COMMON /BOD/ NODTOT,COSTHE(100),SINTHE(100),NFLAG
      COMMON /PAR/ NACA,TAU,EPSMAX,PTMAX
      COMMON /FLAGGER/FIGURE
      COMMON /FINAL/FLAG,XREF,YCORD
      COMMON /COF/ A(101,111),KUTTA
      COMMON /BRAVO/NUMPTS
      COMMON /NUM/ PI,PI2INV
      COMMON /CPD/ CP(100)
      COMMON /PEN/ CLA,CMA,ANGLE,CMB
C
C ***********************************************************************
C   IF USING DATA STMTS FOR X AND Y VALUES, PLACE LINES HERE.
C *** FOLLOWING DATA IS FOR THE NASA LS(1)-0013 AIRFOIL ***
      DATA NUPPER, NLOWER /14,14/
      DATA (X(I),I=1,28)/1.0,.90,.80,.70,.60,.50,.40,.30,.20,.10,
     1 0.07535,0.05,0.0247,0.01255,0.0,0.01301,0.02505,0.04993,0.07498,
     2 0.10,.20,.30,.40,.50,.60,.70,.80,.90/
C *** NOTE:  VALUE FOR TRAILING EDGE IS SET TO 0.000 VS ACT THICKNESS *
      DATA (Y(I),I=1,28)/0.00000,-.01165,-.02654,-.04196,-.05459,
     1        -.06209,-.06453,-.06316,-.05755,-.04543,-.04070,-.03462,
     1        -.02612,-.01938,0.0,.01892,.02583,.03465,.04075,.04541,
     2        .05750,.06307,.06432,.06203,.05446,.04183,.02638,.01172/
C ***********************************************************************
      PI      = 3.1415926585
C *** MAKE SURE THAT N CORRESPONDS TO THE SIZE OF X AND Y DIMENSION **
 59   N = 100
      FLAG = 1
C ***********************************************************************
C
C OPEN FILE FOR BODY SURFACE COORDINATE OUTPUT
 60   OPEN (UNIT=11,
     2      FILE= 'PBODY.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2      STATUS= 'NEW')
C OPEN FILE FOR PRESSURE COEFFICIENT OUTPUT
      OPEN (UNIT=12,
     2      FILE= 'PPRESS.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2      STATUS= 'NEW')
C
C   OPEN ANOTHER FILE FOR BODY SURFACE PRESSURE DISTRIBUTION OUTPUT
      OPEN (UNIT=14,
     2      FILE= 'PRESSER.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2      STATUS= 'NEW')
C
C   OPEN ANOTHER FILE FOR BODY SHAPE OUTPUT
      OPEN (UNIT=15,
     2      FILE= 'BODYSHAPE.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2      STATUS= 'NEW')
C
C
C        OPEN(UNIT=46,FILE='ME4.DAT',STATUS='NEW')
C        DO I= 1,NUMPTS
C         WRITE(46,999)X(I),Y(I)
C        END DO
C        CLOSE(UNIT=46)
      CALL INDATA(X,Y,N,NLOWER,NUPPER)
      IF (FLAG.EQ.2)THEN
        NLOWER = NUMPTS/2
        N = NUMPTS
        NUPPER = NUMPTS/2
C        OPEN(UNIT=43,FILE='ME1.DAT',STATUS='NEW')
C        DO I= 1,NUMPTS
```

```
C         WRITE(43,999)X(I),Y(I)
C        END DO
C        CLOSE(UNIT=43)
      ENDIF
      CALL SETUP(X,Y,N,NLOWER,NUPPER)
C
C  CHECK THE INPUT OF THE AIRFOIL SHAPE DATA(OPTIONAL)
C
C       OPEN (66,FILE='MAKE.DAT',STATUS='NEW')
C       DO I = 1,NUMPTS
C          WRITE(66,999)X(I),Y(I)
C       END DO
  999 FORMAT(1X,F8.4,2X,F8.4)
C       CLOSE (UNIT=66)
C
      IF (FLAG.EQ.2)GO TO 908
 100  PRINT 1000
      READ (5,*) ALPHA
C
C       IF (ALPHA .GT. 90.)    GO TO 200
C
      AOA = ALPHA
      COSALF  = COS(ALPHA*PI/180.)
      SINALF  = SIN(ALPHA*PI/180.)
      CALL COFISH(SINALF,COSALF,X,Y,N,NLOWER,NUPPER)
      CALL GAUSS(1)
C        OPEN(UNIT=45,FILE='ME3.DAT',STATUS='NEW')
C        DO I= 1,NUMPTS
C         WRITE(45,999)X(I),Y(I)
C        END DO
C        CLOSE(UNIT=45)
      CALL VELDIS(SINALF,COSALF,X,Y,N,NLOWER,NUPPER,ALPHA)
      CALL FANDM(SINALF,COSALF,X,Y,N,NLOWER,NUPPER)
200   CONTINUE
      CLOSE(UNIT=11)
      CLOSE(UNIT=12)
      CLOSE(UNIT=14)
      CLOSE(UNIT=15)
 908  IF (FLAG.EQ.2)THEN
        CALL COFISH(SINALF,COSALF,X,Y,N,NLOWER,NUPPER)
        CALL GAUSS(1)
C         OPEN(UNIT=44,FILE='ME2.DAT',STATUS='NEW')
C         DO I= 1,NUMPTS
C          WRITE(44,999)X(I),Y(I)
C         END DO
C         CLOSE(UNIT=44)
        CALL VELDIS(SINALF,COSALF,X,Y,N,NLOWER,NUPPER,ALPHA)
        CALL FANDM(SINALF,COSALF,X,Y,N,NLOWER,NUPPER)
        CLOSE(UNIT=11)
        CLOSE(UNIT=12)
        CLOSE(UNIT=14)
        CLOSE(UNIT=15)
      ENDIF
C  CALL LIBRARY ROUTINE TO CLEAR THE SCREEN, THEN PRINT HEADER
      CALL CLRSCRN
      PRINT *
      PRINT *, ' PROGRAM PANEL RESULTS HAVE BEEN WRITTEN TO FILES:'
      PRINT *
      PRINT *, ' PBODY.DAT    :  BODY SURFACE COORDINATES'
      PRINT *, ' PPRESS.DAT   :  SURFACE PRESSURE DISTRIBUTION'
      PRINT *
      PRINT *
      PRINT *, 'WOULD YOU LIKE TO PRINT THE RESULTS (Y/N)?'
      PRINT *
      READ 1002, PRINT
      IF (PRINT.EQ.'Y'.OR.PRINT.EQ.'y')THEN
      PRINT *
      PRINT *, 'WHICH OF THE FOLLOWING FILES DO YOU WANT?'
      PRINT *
      PRINT *, '             1)  PBODY.DAT'
      PRINT *, '             2)  PPRESS.DAT'
      PRINT *, '   OR        3)  BOTH FILES'
      PRINT *
      PRINT *, 'INPUT OPTION NO.(1,2, OR 3)'
12     READ 1006, PRINTOPT
      IF (PRINTOPT .LT. 1 .OR. PRINTOPT .GT. 3) THEN
         PRINT *, 'INVALID ENTRY, ENTER INTEGER BETWEEN'
         PRINT *, 'ONE(1) AND THREE(3).'
         PRINT *, ' '
         GO TO 12
      ENDIF
      ENDIF
      IF (PRINTOPT .EQ. 1) THEN
         CALL LIB$SPAWN('PRINT PBODY.DAT')
      ENDIF
      IF (PRINTOPT .EQ. 2) THEN
         CALL LIB$SPAWN('PRINT PPRESS.DAT')
      ENDIF
      IF (PRINTOPT .EQ. 3) THEN
         CALL LIB$SPAWN('PRINT PBODY.DAT,PPRESS.DAT')
      ENDIF
      CALL CLRSCRN
      PRINT *
      PRINT *
      PRINT *, 'WOULD YOU LIKE TO GRAPH THE RESULTS (Y/N)?'
      PRINT *
      READ 1002, GRAPH
      IF (GRAPH.EQ.'Y'.OR.GRAPH.EQ.'y')THEN
46    CALL CLRSCRN
      PRINT *
      PRINT *, 'WHICH OF THE FOLLOWING DATA OUTPUTS'
      PRINT *, '      DO YOU WANT TO PLOT?'
      PRINT *
      PRINT *, '   1)  PPRESS.DAT (CP DISTRIBUTION) '
      PRINT *, '   2)  PBODY.DAT (AIRFOIL SHAPE) '
      PRINT *, '   3)  CL VS. ANGLE OF ATTACK '
      PRINT *, '       & CM C/4 VS. ANGLE OF ATTACK '
      PRINT *, '   4)  NONE'
      PRINT *
      PRINT *, 'INPUT OPTION NO.(1,2,3 OR 4)'
65    READ 1006, GRAPHOPT
      IF (GRAPHOPT .LT. 1 .OR. GRAPHOPT .GT. 4) THEN
```

```
            PRINT *, 'INVALID ENTRY, ENTER INTEGER BETWEEN'
            PRINT *, 'ONE(1) AND FOUR(4).'
            PRINT *, ' '
            GO TO 65
         ENDIF
         IF (GRAPHOPT .EQ. 1) THEN
          CALL GRAF1
C     GET A HARDCOPY OF THIS GRAPHIC
          CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
     +SIZE=A P1.UIS')
         PRINT *, ' '
         PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
         PRINT *, ' '
         READ 1002, PLOT1
         IF (PLOT1.EQ.'Y'.OR.PLOT1.EQ.'y')THEN
           CALL LIB$SPAWN('PRINT P1.REN')
         ENDIF
         GO TO 46
         ENDIF
         IF (GRAPHOPT .EQ. 2) THEN
          CALL GRAF2
          CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
     +SIZE=A P2.UIS')
         PRINT *, ' '
         PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
         PRINT *, ' '
         READ 1002, PLOT2
         IF (PLOT2.EQ.'Y'.OR.PLOT2.EQ.'y')THEN
           CALL LIB$SPAWN('PRINT P2.REN')
         ENDIF
         GO TO 46
         ENDIF
         IF (GRAPHOPT .EQ. 3) THEN
C ***********************
         OPEN (UNIT=11,
     2      FILE= 'PBODY.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2      STATUS= 'UNKNOWN')
         OPEN (UNIT=12,
     2      FILE= 'PPRESS.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2      STATUS= 'UNKNOWN')
         OPEN (UNIT=14,
     2      FILE= 'PRESSER.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2      STATUS= 'UNKNOWN')
         OPEN (UNIT=15,
     2      FILE= 'BODYSHAPE.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2      STATUS= 'UNKNOWN')
      DO 45 I = 1,13
       ALPHA = ANGLE(I)
       COSALF  = COS(ALPHA*PI/180.)
       SINALF  = SIN(ALPHA*PI/180.)
       CALL COFISH(SINALF,COSALF,X,Y,N,NLOWER,NUPPER)
       CALL GAUSS(1)
       CALL VELDIS(SINALF,COSALF,X,Y,N,NLOWER,NUPPER,ALPHA)
       CALL FANDM(SINALF,COSALF,X,Y,N,NLOWER,NUPPER)
       CLA(I) = LIFTA
       CMA(I) = MOMENTA
       CMB(I) = MENTA
       CLOSE(UNIT=11)
       CLOSE(UNIT=12)
       CLOSE(UNIT=14)
       CLOSE(UNIT=15)
 45    CONTINUE
      ENDIF
      IF (GRAPHOPT .EQ. 3)THEN
       CALL GRAF3
C     GET A HARDCOPY OF THIS GRAPHIC
       CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
     +SIZE=A P3.UIS')
      PRINT *, ' '
      PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
      PRINT *, ' '
      READ 1002, PLOT3
      IF (PLOT3.EQ.'Y'.OR.PLOT3.EQ.'y')THEN
        CALL LIB$SPAWN('PRINT P3.REN')
      ENDIF
      GO TO 46
      ENDIF
      IF (GRAPHOPT .EQ. 4 .AND. FLAG .EQ. 1) GO TO 68
      IF (GRAPHOPT .EQ. 4 .AND. FLAG .EQ. 2) GO TO 64
      ENDIF
      IF (FLAG.EQ.2)GO TO 64
C
  68  CALL CLRSCRN
      PRINT *, '  '
      PRINT *, '  WOULD YOU LIKE TO ANALYZE VISCOUS EFFECTS'
      PRINT *, '           FOR THIS AIRFOIL (Y/N) ?'
      PRINT *, '  '
      READ 1002, VISCOUS
      IF (VISCOUS.EQ.'Y'.OR.VISCOUS.EQ.'y')THEN
        FLAG = 2
        FIGURE = 2
        PRINT *, '     VISCOUS BOUNDRY LAYER ANALYSIS'
        PRINT *, ' '
        PRINT *, '       *** INPUT DATA OPTION ***'
        PRINT *, ' '
        PRINT *, ' WHAT INPUT SOURCE WOULD YOU LIKE TO USE?'
      PRINT *, ' '
      PRINT *, '   1) DATA FILE "BL2D.DAT" OR '
      PRINT *, '   2) NEW_PANEL CP DISTRIBUTION JUST CREATED'
      PRINT *, '   3) QUIT PROGRAM'
      PRINT *, ' '
      PRINT *, ' ENTER 1, 2, OR 3'
      PRINT *, ' '
 42   READ *, VISOPT
      IF (VISOPT.LT.1.OR.VISOPT.GT.3)THEN
        PRINT *, '    INVALID ENTRY| TRY AGAIN|'
        PRINT *, '        ENTER 1, 2, OR 3'
        GO TO 42
      ENDIF
      IF (VISOPT.EQ.3)GO TO 1111
      CALL CIB(VISOPT)
      PRINT *, ' '
      PRINT *, '  THE BOUNDRY LAYER RESULTS HAVE BEEN '
      PRINT *, '      WRITTEN TO FILE "BL2D.OUT"'
      PRINT *, ' '
      PRINT *, ' WOULD YOU LIKE TO PRINT THESE RESULTS?'
      PRINT *, ' '
      READ 1002, PRINTER
      IF (PRINTER.EQ.'Y'.OR.PRINTER.EQ.'y')THEN
        CALL LIB$SPAWN('PRINT BL2D.OUT')
      ENDIF
      IF (VISOPT.EQ.1)GO TO 64
C
C THE FOLLOWING "GO TO" STATEMENT WAS PUT IN TO CIRCUMVENT
C         PROCESSING THE PANEL METHOD AGAIN.
C
      GO TO 64
C       NUMPTS = NUMPTS-2
C       OPEN(UNIT=63,FILE='VISC.DAT',STATUS='UNKNOWN')
C       READ(63,920)XP,DLSN,THTN
C       READ(63,920)XP,DLSN,THTN
C       READ(63,920)XP,DLSN,THTN
C       DO I=1,INT(NUMPTS/2)
C         READ(63,920)XREF(I),DLS(I),THT(I)
C         XNUM = XREF(I)
C         YYY = YREF(XNUM)
C         YCORD(I)=YYY
C       END DO
C       DO I=(INT(NUMPTS/2)+1),NUMPTS
C         READ(63,920)XREF(I),DLS(I),THT(I)
C         XNUM = XREF(I)
C         YYY = YREF(XNUM)
C         YCORD(I) = -YYY
C       END DO
C     CLOSE(UNIT=63)
C CHECKING THE DATA COORDINATES TO SEE IF IN PROPER ORDER
C     OPEN (UNIT=77,FILE='RET.DAT',STATUS='NEW')
C     DO I=1,NUMPTS
C       WRITE (77,991)XREF(I),YCORD(I)
C991    FORMAT(1X,F8.4,2X,F8.4)
C     END DO
C     CLOSE (UNIT=77)
```

```
C
C      PRINT *, ' '
C      PRINT *, ' WHICH TYPE OF BOUNDRY LAYER THICKNESS'
C      PRINT *, '       WOULD YOU LIKE TO ANALYZE'
C      PRINT *, ' '
C      PRINT *, '          1)  DISPLACEMENT THICKNESS'
C      PRINT *, '          2)  MOMENTUM THICKNESS'
C      PRINT *, '          3)  NONE--QUIT VISCOUS ANALYSIS'
C      PRINT *, '      '
C 69   READ 1006, THICKOPT
C      IF (THICKOPT .LT. 1 .OR. THICKOPT .GT. 3) THEN
C         PRINT *, ' '
C         PRINT *, 'INVALID ENTRY, ENTER INTEGER BETWEEN'
C         PRINT *, '       ONE(1) AND THREE(3).'
C         PRINT *, ' '
C         GO TO 69
C      ENDIF
C      IF (THICKOPT.EQ.1) THEN
C         DO I=1,NUMPTS
C           THICK= DLS(I)
C           IF (YCORD(I).LT.0.)YCOR = YCORD(I)-THICK
C           IF (YCORD(I).GE.0.)YCOR = YCORD(I)+THICK
C           YCORD(I) = YCOR
C         END DO
C      ENDIF
C      IF (THICKOPT.EQ.2) THEN
C         DO I=1,NUMPTS
C           THICK= THT(I)
C           IF (YCORD(I).LT.0.)YCOR = YCORD(I)-ABS(THICK)
C           IF (YCORD(I).GE.0.)YCOR = YCORD(I)+ABS(THICK)
C           YCORD(I) = YCOR
C         END DO
C      ENDIF
C      IF (THICKOPT.EQ.3) GO TO 64
C      GO TO 60
      ENDIF
  64  CALL CLRSCRN
C        OPTION TO MAKE ANOTHER RUN
      PRINT *
      PRINT *, ' DO YOU WISH TO:    '
      PRINT *, '      1) MAKE ANOTHER RUN OR'
      PRINT *, '      2) END THIS SESSION'
      PRINT *, ' ENTER 1 OR 2.'
      CALL QUERY (NANS)
      IF (NANS .EQ. 1)  GO TO 59
 1111 STOP
  920 FORMAT(1X,F8.4,2E11.4)
  930 FORMAT(1X,F8.4,F11.6)
 1000 FORMAT(/////,' INPUT ALPHA IN DEGREES  ')
 1002 FORMAT(A1)
 1006 FORMAT(I1)
      END
C *******************************************************************
C     DATA VALUES FOR VARIOUS AIRFOILS. TO USE, REMOVE COMMENTS
C     AND PLACE AFTER COMMON CARDS IN MAIN PROGRAM.
C *******************************************************************
```

```
C *** FOLLOWING DATA IS FOR THE NACA 0006 AIRFOIL ***
C     DATA NUPPER, NLOWER /14,14/
C     DATA (X(I),I=1,28)/1.0,.90,.80,.70,.60,.50,.40,.30,.20,.10,
C    1 0.075,0.05,0.025,0.0125,0.0,0.0125,0.025,0.05,0.075,
C    2 0.10,.20,.30,.40,.50,.60,.70,.80,.90/
C *** NOTE: VALUE FOR TRAILING EDGE IS SET TO 0.000 VS ACT THICKNESS *
C     DATA (Y(I),I=1,20)/-.00063,-.00724,-.01312,-.01832,-.02282,
C    1        -.02647,-.02902,-.03001,-.02869,-.02341,0.0,.02341,.02869,
C    2         .03001,.02902,.02647,.02282,.01832,.01312,.00724/
C
C ***************************************************************************
C *** FOLLOWING DATA IS FOR THE NACA 0012 AIRFOIL ***
C     DATA NUPPER, NLOWER /14,14/
C     DATA (X(I),I=1,28)/1.0,.90,.80,.70,.60,.50,.40,.30,.20,.10,
C    1 0.075,0.05,0.025,0.0125,0.0,0.0125,0.025,0.05,0.075,
C    2 0.10,.20,.30,.40,.50,.60,.70,.80,.90/
C *** NOTE: VALUE FOR TRAILING EDGE IS SET TO 0.000 VS ACT THICKNESS *
C     DATA (Y(I),I=1,28)/0.00000,-.01448,-.02623,-.03664,-.04563,
C    1        -.05294,-.05803,-.06002,-.05737,-.04683,-.04200,-.03555,
C    1        -.02615,-.01894,0.0,.01894,.02615,.03555,.04200,.04683,
C    2         .05737,.06002,.05803,.05294,.04563,.03664,.02623,.01448/
C
C ***************************************************************************
C *** FOLLOWING DATA IS FOR THE NASA LS(1)-0013 AIRFOIL ***
C     DATA NUPPER, NLOWER /14,14/
C     DATA (X(I),I=1,28)/1.0,.90,.80,.70,.60,.50,.40,.30,.20,.10,
C    1 0.07535,0.05,0.0247,0.01255,0.0,0.01301,0.02505,0.04993,0.07498,
C    2 0.10,.20,.30,.40,.50,.60,.70,.80,.90/
C *** NOTE: VALUE FOR TRAILING EDGE IS SET TO 0.000 VS ACT THICKNESS *
C     DATA (Y(I),I=1,28)/0.00000,-.01165,-.02654,-.04196,-.05459,
C    1        -.06209,-.06453,-.06316,-.05755,-.04543,-.04070,-.03462,
C    1        -.02612,-.01938,0.0,.01892,.02583,.03465,.04075,.04541,
C    2         .05750,.06307,.06432,.06203,.05446,.04183,.02638,.01172/
C ****************************************************************************
*     USER INSTRUCTIONS FOR MANUAL DATA ENTRY:                             *
*                                                                          *
*         (1) UPON CUE ENTER THE TOTAL NUMBER OF AIRFOIL DATA              *
*     POINTS.  DO NOT COUNT THE LEADING OR TRAILING EDGE TWICE.            *
*                                                                          *
*     NOTE: ARRAYS ARE DIMENSIONED TO 100, THIS IS, THEREBY THE            *
*           LIMITING NUMBER OF DATA POINTS THAT CAN BE ENTERED             *
*           WITHOUT HAVING TO REDIMENSION THE PROGRAMS ARRAYS.             *
*                                                                          *
*         (2) ENTER X COORDINATES AS MANY TO A LINE AS DESIRED.            *
*     THE PROGRAM WILL ALLOW FOR CORRECTION IF ANY ERRORS ARE              *
*     MADE. A TABLE OF X COORDINATES IS DISPLAYED FOR THE USER             *
*     TO CHECK HIS INPUT.                                                  *
*                                                                          *
*         (3) ENTER Y COORDINATES AS MANY TO A LINE AS DESIRED.            *
*     THE PROGRAM WILL ALLOW FOR CORRECTION IF ANY ERRORS ARE              *
*     MADE. A TABLE OF Y COORDINATES IS DISPLAYED FOR THE USER             *
*     TO CHECK HIS INPUT.                                                  *
*                                                                          *
*         (4) PROGRAM ALLOWS FOR AS MANY RUNS AS THE USER DESIRES          *
*     SIMPLY FOLLOW CUING SEQUENCE.                                        *
*                                                                          *
****************************************************************************

      SUBROUTINE BL
C
      COMMON /BLC2/ NX,NXT,NP,NPT,NTR,IT,ISF
      COMMON /BLC3/ X(100),UE(100),P1(100),P2(100),GMTR(100)
      COMMON /BLC7/ ETA(101),DETA(101),A(101)
      COMMON /BLC8/ F(101,2),U(101,2),V(101,2),B(101,2)
      COMMON /BLC6/ DELF(101),DELU(101),DELV(101)
C
      NX =0
      ITMAX = 10
      IGROWT = 2
      EPSL = .0001
      EPST = .01
      NPT  = 101
C
C     ETA-GRID NETWORK
C
      ETAE = 8.
      VGP  = 1.1
      DETA(1) = .01
      NP = ALOG((ETAE/DETA(1))*(VGP-1.)+1.)/ALOG(VGP) +1.001
      ETA(1) = 0.
      DO 10 J = 2,NPT
        ETA(J) = ETA(J-1) + DETA(J-1)
        DETA(J) = VGP*DETA(J-1)
        A(J) = .5*DETA(J-1)
   10 CONTINUE
C
C     INITIAL LAMINAR VELOCITY PROFILE
C
      DO 20 J = 1,NP
        ETAB = ETA(J)/ETA(NP)
        ETAB2 = ETAB**2
        F(J,2) = .25*ETA(NP)*ETAB2*(3.- .5*ETAB2)
        U(J,2) = .5*ETAB*(3.  - ETAB2)
        V(J,2) = 1.5 *(1.  - ETAB2)/ETA(NP)
        B(J,2) = 1.
   20 CONTINUE
C
    1 NX = NX+1
      IGROW = 0
      IT = 0
C
    5 IT = IT+1
C      WRITE(*,*)IT
      IF (IT.GT. ITMAX) GO TO 101
        IF(NX.GE.NTR) CALL EDDY
          CALL COEF
          CALL SOLV3
C
C     CHECK FOR CONVERGENCE
C
      IF (NX .LT. NTR) THEN
```

```
          IF (ABS(DELV(1)) .GT. EPSL) GO TO 5
        ELSE
          IF (ABS(DELV(1)/V(1,2)) .GT. EPST) GO TO 5
        ENDIF
C
C       PROFILES FOR GROWTH
C
        DO 30 J = NP+1,NPT
          F(J,2) = F(J-1,2) + DETA(J-1)*U(J-1,2)
          U(J,2) = U(J-1,2)
          V(J,2) = 0.
          B(J,2) = B(J-1,2)
   30   CONTINUE
C
C       CHECK FOR GROWTH
C
        IF (ABS(V(NP,2)) .GT. .0005 .OR. ABS(1.-U(NP-2,2)/U(NP,2))
       + .GT. .005) THEN
         NP = NP + 2
         IGROW = IGROW + 1
         IF (NP .LE. NPT .AND. IGROW .LE. IGROWT) THEN
           IT = 0
           GO TO 5
         ENDIF
        ENDIF
C
  101   CALL OUTPUT
        IF (NX .LT. NXT) GO TO 1
C
        RETURN
        END

        SUBROUTINE BODY(Z,SIGN,XI,YI)
C
C               RETURN COORDINATES OF POINT ON THE BODY SURFACE
C
C                    Z = NODE-SPACING PARAMETER
C                    X,Y = CARTESIAN COORDINATES
C                    SIGN = +1. FOR UPPER SURFACE
C                           -1. FOR LOWER SURFACE
C
        COMMON /PAR/ NACA,TAU,EPSMAX,PTMAX
        IF (SIGN .LT. 0.0)    Z = 1. - Z
        CALL NACA45(Z,THICK,CAMBER,BETA)
        XI      = Z - SIGN*THICK*SIN(BETA)
        YI      = CAMBER + SIGN*THICK*COS(BETA)
        RETURN
        END
C
        SUBROUTINE NACA45(Z,THICK,CAMBER,BETA)
C
        COMMON /PAR/ NACA,TAU,EPSMAX,PTMAX
C
C               EVALUATE THICKNESS AND CAMBER
C               FOR NACA 4- OR 5-DIGIT AIRFOIL
C
```

```
      THICK    = 0.0
      IF (Z .LT. 1.E-10)      GO TO 100
      THICK    = 5.*TAU*(.2969*SQRT(Z) - Z*(.126 + Z*(.3537
     +           - Z*(.2843 - Z*.1015))))
 100  IF (EPSMAX .EQ. 0.0) GO TO 130
      IF (NACA .GT. 9999) GO TO 140
      IF (Z .GT. PTMAX) GO TO 110
      CAMBER   = EPSMAX/PTMAX/PTMAX*(2.*PTMAX - Z)*Z
      DCAMDX   = 2.*EPSMAX/PTMAX/PTMAX*(PTMAX - Z)
      GO TO 120
 110  CAMBER   = EPSMAX/(1.-PTMAX)**2*(1. + Z - 2.*PTMAX)*(1. - Z)
      DCAMDX   = 2.*EPSMAX/(1.-PTMAX)**2*(PTMAX - Z)
 120  BETA     = ATAN(DCAMDX)
      RETURN
 130  CAMBER   = 0.0
      BETA     = 0.0
      RETURN
 140  IF (Z .GT. PTMAX)       GO TO 150
      W        = Z/PTMAX
      CAMBER   = EPSMAX*W*((W - 3.)*W + 3. - PTMAX)
      DCAMDX   = EPSMAX*3.*W*(1. - W)/PTMAX
      GO TO 120
 150  CAMBER   = EPSMAX*(1. - Z)
      DCAMDX   = - EPSMAX
      GO TO 120
      END

C         PROGRAM CEBECI
C
C           THIS PROGRAM REPRESENTS AN ADAPTATION OF A VISCOUS
C     BOUNDARY LAYER PROGRAM CURRENTLY ON THE IBM 3033.  GIVEN A
C     COEFFICIENT OF PRESSURE DISTRIBUTION ABOUT AN AIRFOIL/WING,
C     THIS PROGRAM WILL DETERMINE THE RELATIVE BOUNDARY LAYER
C     THICKNESS ALONG THE CHORD AND THE COEFFICIENT OF FRICTION
C     AT THE SAME POSITION.
C
      SUBROUTINE CIB(OPTION)
C
      COMMON /BLCO/ RL,NBL(2),XCTRI(2)
      COMMON /BLC1/ ITR,XCTR,XC(100),YC(100)
      COMMON /BLC2/ NX,NXT,NP,NPT,NTR,IT,ISF
      COMMON /BLC3/ X(100),UE(100),P1(100),P2(100),GMTR(100)
      COMMON /BLCS/ DLS(100),VW(100),CF(100),THT(100)
      COMMON /VISCOUS/XCORD,YCOR,CPDAT
      COMMON /BRAVO/NUMPTS
      COMMON /FRIC/ DSKIN,DFORM
      DIMENSION NXTSF(2),XI(200),YI(200),VEI(200),VEL(200)
      DIMENSION XCORD(100),YCOR(100),CPDAT(100)
      INTEGER OPTION
C
      OPEN (UNIT=9,FILE='BL2D.DAT',STATUS='UNKNOWN')
      OPEN (UNIT=8,FILE='BL2D.OUT',STATUS='UNKNOWN')
      OPEN (UNIT=62,FILE='VIS.DAT',STATUS='UNKNOWN')
      OPEN (UNIT=63,FILE='VISC.DAT',STATUS='UNKNOWN')
C  UNIT=62 IS A CHECKING FILE
      IF (OPTION.EQ.2)THEN
```

```
          DO  I = 1,NUMPTS
            VEI(I)=SQRT(1-CPDAT(I))
          END DO
C          WRITE(62,777)(VEI(I),I=1,NUMPTS)
C  777     FORMAT(1X,F10.5)
          NUMBER = 1
          DUMMY = VEI(1)
          DO I = 2,NUMPTS
            IF (DUMMY.GT.VEI(I))THEN
              DUMMY=VEI(I)
              NUMBER=I
            ENDIF
          END DO
          IS = NUMBER
          CALL CLRSCRN
          PRINT *, ' '
          PRINT *, ' ENTER THE FLOW REYNOLDS NUMBER'
          PRINT *, '          IE. 6000000.'
          PRINT *, ' '
          READ *, RL
          PRINT *, ' '
          PRINT *, ' ENTER THE TRANSITION POINT ON THE '
          PRINT *, '       UPPER SURFACE(E.G. 0.3)'
          PRINT *, ' '
          READ *, XCTRI(1)
          PRINT *, ' ENTER THE TRANSITION POINT ON THE '
          PRINT *, '       LOWER SURFACE(E.G. 0.3)'
          PRINT *, ' '
          READ *, XCTRI(2)
          WRITE(6,*) 'READING THE DATA...'
C  CHECK INPUT DATA BY WRITING IT INTO UNIT = 62
  18      FORMAT(1X,3F10.5)
  19      FORMAT(1X,F10.1,2F10.5)
C          WRITE(62,19)RL,XCTRI(1),XCTRI(2)
C          WRITE(62,10)NUMPTS,IS
          NI = NUMPTS
          NOT = 1
          NAY = 1
   66     IF (NOT.LE.NUMPTS)THEN
            WRITE(62,18)XCORD(NOT),YCOR(NOT),VEI(NOT)
            XI(NAY) = XCORD(NOT)
            YI(NAY) = YCOR(NOT)
            VEI(NAY)= SQRT(1-CPDAT(NOT))
            VEL(NAY)= SQRT(1-CPDAT(NOT))
            NAY = NAY + 1
            NOT = NOT + 1
            GO TO 66
          ENDIF
C  CHECK DATA
C       OPEN (UNIT=87,FILE='CHECK1.DAT',STATUS='NEW')
C       DO I=1,NUMPTS
C         WRITE (87,991)XCORD(I),YCOR(I),VEI(I),XI(I),YI(I)
C 991     FORMAT(1X,5F8.4)
C       END DO
C       CLOSE (UNIT=87)
C
```

```
        DO I=1,INT(NUMPTS/2)
          CAN1 = XCORD(I)
          CAN2 = YCOR(I)
          CAN3 = VEL(I)
          XI(I+1)=CAN1
          YI(I+1)=CAN2
          VEI(I+1)=CAN3
        END DO
        DO I=INT(NUMPTS/2)+1,NUMPTS
          CAN1 = XCORD(I)
          CAN2 = YCOR(I)
          CAN3 = VEL(I)
          XI(I+2)=CAN1
          YI(I+2)=CAN2
          VEI(I+2)=CAN3
        END DO
        XI(1)=1.
        YI(1)=0.
        VEI(1)=.97*VEI(1)
        XI(NUMPTS/2+2)=0.
        YI(NUMPTS/2+2)=0.
        VEI(NUMPTS/2+2)=(VEI(NUMPTS/2+1)+VEI(NUMPTS/2+3))/2.
        XI(NUMPTS+3)=1.000
        YI(NUMPTS+3)=0.000
        VEI(NUMPTS+3)=.98*VEI(NUMPTS+2)
        NUMPTS = NUMPTS+3
        NI = NUMPTS
C  CHECK DATA
C       PRINT *,NUMPTS
C       PRINT *,NI
C       OPEN (UNIT=88,FILE='CHECK2.DAT',STATUS='NEW')
C       DO I=1,NUMPTS
C         WRITE (88,996)XI(I),YI(I),VEI(I)
C 996     FORMAT(1X,3F8.4)
C       END DO
        ELSE
          WRITE(6,*) 'READING THE DATA...'
          READ (9,15) RL,XCTRI(1),XCTRI(2)
          READ (9,10) NI,IS
          READ (9,15) (XI(I),YI(I),VEI(I),I=1,NI)
        ENDIF
       DO I=1,NI
           WRITE(62,18)XI(I),YI(I),VEI(I)
       END DO
 65    WRITE (6,*) 'INPUT OF DATA COMPLETE.'
       WRITE (8,90) RL,XCTRI(1),XCTRI(2)
       NXTSF(1) = NI - IS + 1
       NXTSF(2) = IS
C
C      DATA FOR EACH SURFACE
C
       DO 200 ISF = 1,2
         NXT = NXTSF(ISF)
         GO TO (201,202), ISF
C
```

```
C     UPPER SURFACE
C
  201 II = IS -1
      DO 211 I = 1,NXT
        II = II+1
        XC(I) = XI(II)
        YC(I) = YI(II)
        UE(I) = VEI(II)
  211 CONTINUE
      GO TO 300
C
C     LOWER SURFACE
C
  202 II = IS + 1
      DO 212 I = 1,NXT
        II = II - 1
        XC(I) = XI(II)
        YC(I) = YI(II)
        UE(I) = VEI(II)
  212 CONTINUE
C
  300 X(1) = 0.
      DO 301 I = 2,NXT
  301 X(I) = X(I-1)+SQRT((XC(I)-XC(I-1))**2+(YC(I)-YC(I-1))**2)
C
C     TRANSITION LOCATION
C
      DO 320 I = 1,NXT
        GMTR(I) = 0.
        IF (XC(I) .GE. XCTRI(ISF)) GO TO 321
  320 CONTINUE
  321 NTR = I
      PGAMTR = 1200.
      RXNTR = X(NTR-1) * UE(NTR-1) * RL
C     CLOSE (UNIT=88)
      GGFT = RL*RL/RXNTR**1.34*UE(NTR-1)*UE(NTR-1)*UE(NTR-1)
      UEINTG = 0.
      U1 = .5/UE(NTR-1)/PGAMTR
      DO 322 I = NTR,NXT
        U2   = .5/UE(I)/PGAMTR
        UEINTG = UEINTG + (U1 + U2)*(X(I)-X(I-1))
        U1 =U2
        GG = GGFT*UEINTG*(X(I)-X(NTR-1))
        IF (GG .GT. 10.) GO TO 323
          GMTR(I) = 1. - EXP(-GG)
  322 CONTINUE
  323 DO 324 II = I,NXT
  324 GMTR(II) = 1.
C
C     PRESSURE GRADIENT PARAMETERS
C
      DX = X(2) - X(1)
      DUE = UE(2) - UE(1)
      ANG2 = ATAN2(DUE,DX)
      DL2 = DX
      DO 331 I = 2,NXT-1
```

```
          ANG1 =ANG2
          DL1  =  DL2
          DX = X(I+1) - X(I)
          DUE = UE(I+1) - UE(I)
          ANG2 = ATAN2(DUE,DX)
          DL2 = DX
          ANG = (DL2*ANG1+DL1*ANG2)/(DL1+DL2)
          P2(I) = TAN(ANG)
  331 CONTINUE
        P2(NXT) = 2.*DUE/DL2 - P2(NXT-1)
        DO 330 I = 2,NXT
          P2(I) = X(I) * P2(I) /UE(I)
          P1(I) = .5 * (1. + P2(I))
  330 CONTINUE
        P2(1) = 1.
        P1(1) = .5 * (1.+ P2(1))
C
C       BOUNDRY LAYER CALCULATION
C
        WRITE(6,*) 'BOUNDRY LAYER COMPUTATIONS IN PROGRESS,..'
        CALL BL
C INSERTED ABS FOR CHECKING PURPOSES ONLY
        WRITE (8,910) ISF,(I,XC(I),X(I),VW(I),CF(I),DLS(I),THT(I),
     +  I=1,NXT)
        WRITE(63,920)(XC(I),ABS(DLS(I)),ABS(THT(I)),I=1,NXT)
  200 CONTINUE
        CALL DRAG
        WRITE(8,103)DSKIN,DFORM
C
        CLOSE(UNIT = 8)
        CLOSE(UNIT = 9)
        CLOSE(UNIT = 62)
        CLOSE(UNIT = 63)
   10   FORMAT(2I5)
   15   FORMAT(3F10.0)
   90   FORMAT(//5X,'RL =',E12.5,5X,'XCTRI(1) =',F8.3,5X,
     + 'XCTR(2) =',F8.3)
  103 FORMAT(//,6X,' TOTAL SKIN DRAG = ',F10.6,
     +          /,6X,' TOTAL FORM DRAG = ',F10.6)
  910 FORMAT(///2X,'*** SUMMARY OF BOUNDRY LAYER SOLUTIONS OF ISF = '
     + ,I2,//2X,'NX',4X,'XC',8X,'S',8X,'VW',8X,'CF',8X,'DLS',8X,'THT'
     + ,/(I5,2F8.4,4E11.4))
 920  FORMAT(1X,F8.4,2E11.4)
        RETURN
        END

        SUBROUTINE CLRSCRN
C
C  LIBRARY ROUTINE TO CLEAR THE SCREEN.
C
        ISTAT = LIB$ERASE_PAGE (1,1)
        RETURN
        END

        SUBROUTINE QUERY(NANS)
C
```

```
C  ROUTINE TO TRAP ERRORS CAUSED BY IMPROPER RESPONSES TO QUESTIONS.
C  THE COMPUTER GENERATES AND ERROR WHEN A CHARACTER IS SUPPLIED TO
C  A QUESTION EXPECTING AN INTEGER OR REAL VALUE.
C
      NQTEST=0
    1 CONTINUE
      IF (NQTEST .GT. 0) THEN
         PRINT *, '  CHARACTER VALUES ARE NOT VALID.'
         PRINT *, '  PLEASE ENTER AN INTEGER VALUE.'
      END IF
      NQTEST = NQTEST + 1
      READ (5,*,ERR=1)NANS
      RETURN
      END

      SUBROUTINE COEF
C
      COMMON /BLC2/ NX,NXT,NP,NPT,NTR,IT,ISF
      COMMON /BLC3/ X(100),UE(100),P1(100),P2(100),GMTR(100)
      COMMON /BLC7/ ETA(101),DETA(101),A(101)
      COMMON /BLC8/ F(101,2),U(101,2),V(101,2),B(101,2)
      COMMON /BLC9/ S1(101),S2(101),S3(101),S4(101),S5(101),
     +S6(101),S7(101),S8(101),R1(101),R2(101),R3(101),R4(101)
C
      P1H = .5*P1(NX)
      IF (NX .EQ. 1) THEN
        CEL = 0.
        CELH = 0.
        DO 5 J=1,NP
         F(J,1) = 0.
         U(J,1) = 0.
         V(J,1) = 0.
         B(J,1) = 0.
    5   CONTINUE
      ELSE
        CEL = .5 * (X(NX)+X(NX-1))/(X(NX)-X(NX-1))
        CELH= .5 * CEL
      ENDIF
C
      DO 100 J = 2,NP
C
C     CURRENT STATION
C
      FB    = .5*(F(J,2) + F(J-1,2))
      UB    = .5*(U(J,2) + U(J-1,2))
      FVB   = .5*(F(J,2)*V(J,2)+F(J-1,2)*V(J-1,2))
      VB    = .5*(V(J,2) + V(J-1,2))
      USB   = .5*(U(J,2)**2 + U(J-1,2)**2)
      DERBV= (B(J,2)*V(J,2) - B(J-1,2)*V(J-1,2))/DETA(J-1)
C
C     PREVIOUS STATION
C
      CFB    = .5*(F(J,1) + F(J-1,1))
      CUB    = .5*(U(J,1) + U(J-1,1))
      CVB    = .5*(V(J,1) + V(J-1,1))
      CUSB   = .5*(U(J,1)**2 + U(J-1,1)**2)
      CFVB   = .5*(F(J,1)*V(J,1)+F(J-1,1)*V(J-1,1))
      CDERBV= (B(J,1)*V(J,1) - B(J-1,1)*V(J-1,1))/DETA(J-1)
C
C     S- COEFFICIENTS
C
      S1(J) = CELH*(F(J,2) - CFB) + P1H*F(J,2)+
     +B(J,2)/DETA(J-1)
      S2(J) = CELH*(F(J-1,2) - CFB) +P1H*F(J-1,2)-
     +  B(J-1,2)/DETA(J-1)
      S3(J) = CELH*(V(J,2) + CVB) + P1H*V(J,2)
      S4(J) = CELH*(V(J-1,2) +CVB) + P1H*V(J-1,2)
      S5(J) = -(CEL+P2(NX))*U(J,2)
      S6(J) = -(CEL+P2(NX))*U(J-1,2)
C
C     R- COEFFICIENTS
C
      IF (NX .EQ. 1) THEN
        CRB = -P2(NX)
        R2(J) = CRB - (DERBV + P1(NX) * FVB - P2(NX)*USB)
      ELSE
        CLB =CDERBV + P1(NX-1)*CFVB - P2(NX-1)*CUSB +
     +    P2(NX-1)
        CRB = -CLB - CEL*CUSB - P2(NX)
        R2(J) = CRB - (DERBV +P1(NX)*FVB - (CEL+P2(NX))*
     +  USB + CEL*(FVB + CVB*FB - VB*CFB - CFVB))
      ENDIF
      R1(J)   = F(J-1,2) - F(J,2) + DETA(J-1)*UB
      R3(J-1) = U(J-1,2) - U(J,2) + DETA(J-1)*VB
  100 CONTINUE
C
C     BOUNDRY CONDITIONS
C
      R1(1)  = 0.
      R2(1)  = 0.
      R3(NP) = 0.
C
      RETURN
      END

      SUBROUTINE COFISH(SINALF,COSALF,X,Y,N,NLOWER,NUPPER)
C
C              SET COEFFICIENTS OF LINEAR SYSTEM
C
      REAL X(N),Y(N)
      COMMON /BOD/ NODTOT,COSTHE(100),SINTHE(100),NFLAG
      COMMON /COF/ A(101,111),KUTTA
      COMMON /NUM/ PI,PI2INV
      KUTTA   = NODTOT + 1
C
C              INITIALIZE COEFFICIENTS
C
      DO 90   J = 1,KUTTA
 90   A(KUTTA,J)   = 0.0
C
C              SET VN = 0 AT MID-POINT OF I-TH PANEL
C
```

```
      DO 120  I = 1,NODTOT
      XMID    = .5*(X(I) + X(I+1))
      YMID    = .5*(Y(I) + Y(I+1))
      A(I,KUTTA) = 0.0
C
C             --   FIND CONTRIBUTION OF J-TH PANEL
C
      DO 110  J = 1,NODTOT
      FLOG    = 0.0
      FTAN    = PI
      IF (J .EQ. I)     GO TO 100
      DXJ     = XMID - X(J)
      DXJP    = XMID - X(J+1)
      DYJ     = YMID - Y(J)
      DYJP    = YMID - Y(J+1)
      FLOG    = .5*ALOG((DXJP*DXJP+DYJP*DYJP)/(DXJ*DXJ+DYJ*DYJ))
      FTAN    = ATAN2(DYJP*DXJ-DXJP*DYJ,DXJP*DXJ+DYJP*DYJ)
 100  CTIMTJ  = COSTHE(I)*COSTHE(J) + SINTHE(I)*SINTHE(J)
      STIMTJ  = SINTHE(I)*COSTHE(J) - COSTHE(I)*SINTHE(J)
      A(I,J)  = PI2INV*(FTAN*CTIMTJ + FLOG*STIMTJ)
      B       = PI2INV*(FLOG*CTIMTJ - FTAN*STIMTJ)
      A(I,KUTTA) = A(I,KUTTA) + B
      IF ((I .GT. 1) .AND. (I .LT. NODTOT))GO TO 110
C
C             --   IF I-TH PANEL TOUCHES TRAILING EDGE,
C                  ADD CONTRIBUTION TO KUTTA CONDITION
C
      A(KUTTA,J) = A(KUTTA,J) - B
      A(KUTTA,KUTTA) = A(KUTTA,KUTTA) + A(I,J)
 110  CONTINUE
C
C             FILL IN KNOWN SIDES
C
      A(I,KUTTA+1) = SINTHE(I)*COSALF - COSTHE(I)*SINALF
 120  CONTINUE
      A(KUTTA,KUTTA+1) = - (COSTHE(1) + COSTHE(NODTOT))*COSALF
     +                   - (SINTHE(1) + SINTHE(NODTOT))*SINALF
      RETURN
      END

      SUBROUTINE DRAG
C
C  THE PURPOSE OF THIS SUBROUTINE IS TO CALCULATE THE TOTAL
C  FORM DRAG AND THE TOTAL SKIN DRAG GIVEN THE BOUNDRY LAYER
C  CHARACTERISTICS FROM SUBROUTINE CIB.
      COMMON /BLC1/ ITR,XCTR,XC(100),YC(100)
      COMMON /BLC2/ NX,NXT,NP,NPT,NTR,IT,ISF
      COMMON /BLC3/ X(100),UE(100),P1(100),P2(100),GMTR(100)
      COMMON /BLCS/ DLS(100),VW(100),CF(100),THT(100)
      COMMON /FRIC/ DSKIN,DFORM
      DSKIN =0.
      T1    =0.
      DO  I=2,NXT
        T2 = CF(I)*UE(I)**2
        DSKIN = DSKIN + .5*(T1+T2)*(XC(I)-XC(I-1))
        T1 = T2
      END DO
      HTE = DLS(NXT)/THT(NXT)
      DFORM = 2. * THT(NXT)*UE(NXT)**(.5*(5.+HTE))
      RETURN
      END

      SUBROUTINE EDDY
C
      COMMON /BLCO/ RL,NBL(2),XCTRI(2)
      COMMON /BLC2/ NX,NXT,NP,NPT,NTR,IT,ISF
      COMMON /BLC3/ X(100),UE(100),P1(100),P2(100),GMTR(100)
      COMMON /BLC7/ ETA(101),DETA(101),A(101)
      COMMON /BLC8/ F(101,2),U(101,2),V(101,2),B(101,2)
      DIMENSION EDVI(101)
C
      RL2  = SQRT(RL*UE(NX)*X(NX))
      RL4  = SQRT(RL2)
      RL216 = .16 * RL2
C
      ALFA = .0168
      EDVO = ALFA*RL2*GMTR(NX)*(U(NP,2)*ETA(NP)-F(NP,2))
      EDVI(1) = 0.
      YBAJ = RL4*SQRT(ABS(V(1,2)))/26.
      DO 70 J = 2,NP
        JJ  = J
        YBA = YBAJ*ETA(J)
        EL = 1.
        IF(YBA .LT. 10.) EL = 1. - EXP(-YBA)
          EDVI(J) = RL216*GMTR(NX)*(EL*ETA(J))**2 * ABS(V(J,2))
          IF (EDVI(J) .GT. EDVO) GO TO 90
          IF (EDVI(J) .LE. EDVI(J-1)) EDVI(J) = EDVI(J-1)
          B(J,2) = 1. + EDVI(J)
   70 CONTINUE
   90 DO 100 JJ=J,NPT
  100 B(JJ,2) = 1. + EDVO
      B(1,2) = 1.
C
      RETURN
      END

      SUBROUTINE FANDM(SINALF,COSALF,X,Y,N,NLOWER,NUPPER)
C
C             COMPUTE AND PRINT OUT CD,CL,CM
C
      REAL X(N),Y(N)
      REAL LIFTA,MOMENTA,MENTA
      COMMON /EXTRA/LIFTA,MOMENTA,MENTA
      COMMON /BOD/ NODTOT,COSTHE(100),SINTHE(100),NFLAG
      COMMON /CPD/ CP(100)
      CFX     = 0.0
      CFY     = 0.0
      CM      = 0.0
      CMC4    = 0.0
      DO 100  I = 1,NODTOT
      XMID    = .5*(X(I) + X(I+1))
      YMID    = .5*(Y(I) + Y(I+1))
      DX      = X(I+1) - X(I)
      DY      = Y(I+1) - Y(I)
      CFX     = CFX + CP(I)*DY
      CFY     = CFY - CP(I)*DX
      CM      = CM + CP(I)*(DX*XMID + DY*YMID)
      CMC4    = CMC4 + CP(I)*(DX*(XMID-0.25) + DY*YMID)
  100 CONTINUE
      CD      = CFX*COSALF + CFY*SINALF
      CL      = CFY*COSALF - CFX*SINALF
      LIFTA   = CL
      MENTA   = CM
      MOMENTA = CMC4
      PRINT 1000, CD,CL,CM,CMC4
      WRITE (12,1000) CD,CL,CM,CMC4
 1000 FORMAT(/////,10X,'    CD =',F8.5,'     CL =',F8.5,//,10X,
     +'    CM =',F8.5,'    CMC4 =',F8.5)
      RETURN
      END

      SUBROUTINE GAUSS (NRHS)
C
C         SOLUTION OF LINEAR ALGEBRAIC SYSTEM BY
C         GAUSS ELIMINATION WITH PARTIAL PIVOTING
C
C              °A         = COEFFICIENT MATRIX
C              NEQNS      = NUMBER OF EQUATIONS
C              NRHS       = NUMBER OF RIGHT HAND SIDES
C
C              RIGHT-HAND SIDES AND SOLUTIONS STORED IN
C              COLUMNS NEQNS+1 THRU NEQNS+NRHS OF °A
C
      COMMON DX,DY,AR,PI
      COMMON /COF/ A(350,351),NEQNS
      NP      = NEQNS + 1
      NTOT    = NEQNS + NRHS
C
C              GAUSS REDUCTION
C
      DO 150  I = 2,NEQNS
C
C              --  SEARCH FOR LARGEST ENTRY IN (I-1)TH COLUMN
C                  ON OR BELOW MAIN DIAGONAL
C
        IM      = I - 1
        IMAX    = IM
        AMAX    = ABS(A(IM,IM))
        DO 110  J = I,NEQNS
          IF (AMAX .GE. ABS(A(J,IM))) GO TO 110
          IMAX    = J
          AMAX    = ABS(A(J,IM))
  110   CONTINUE
C
C              --   SWITCH (I-1)TH AND IMAXTH EQUATIONS
C
        IF (IMAX .NE. IM)   GO TO 140
        DO 130  J = IM,NTOT
```

```
          TEMP     = A(IM,J)
          A(IM,J) = A(IMAX,J)
          A(IMAX,J) = TEMP
 130    CONTINUE
C
C              ELIMINATE (I-1)TH UNKNOWN FROM
C              ITH THRU (NEQNS)TH EQUATIONS
C
 140  DO 150  J = I,NEQNS
              R = A(J,IM)/A(IM,IM)
        DO 150  K = I,NTOT
 150       A(J,K) = A(J,K) - R*A(IM,K)
C
C              BACK SUBSTITUTION
C
      DO 220  K = NP,NTOT
        A(NEQNS,K) = A(NEQNS,K)/A(NEQNS,NEQNS)
        DO 210  L = 2,NEQNS
          I       = NEQNS + 1 - L
          IP      = I + 1
          DO 200  J = IP,NEQNS
 200        A(I,K)  = A(I,K) - A(I,J)*A(J,K)
 210        A(I,K)  = A(I,K)/A(I,I)
 220  CONTINUE
      RETURN
      END

      SUBROUTINE GRAF1
C
C    DEFINE IPACK ARRAY FOR LEGEND
      INTEGER*4 IPACK(35)
      INTEGER NUM
      REAL XX(100),CP(100),MAX,MIN,AIR
      CHARACTER*40 L1
      COMMON /ABLE/NUM
      COMMON /BOD/ NODTOT,COSTHE(100),SINTHE(100),NFLAG
      COMMON /BRAVO/NUMPTS
      COMMON /PAR/ NACA,TAU,EPSMAX,PTMAX
      COMMON /CHARLIE/ AIR
      COMMON /CRAIG/CP
C    READ ELEMENTS OF UNIT 14 INTO ARRAYS TO PLOT
       OPEN(UNIT=14,FILE='PRESSER.DAT',STATUS='OLD')
       DO 25 I = 1,NUM
         READ(14,*)XX(I),CP(I)
 25    CONTINUE
       CLOSE(UNIT=14)
       CALL FORM1(MAX,MIN)
C    DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
       L1 = 'LOWER AND UPPER AIRFOIL POINTS$'
C    INITIALIZE THE GRAPHICS SYSTEM
       CALL INIT
C    LABEL X AND Y AXES USING SELF COUNTING STRINGS
       CALL XNAME('X$',100)
       CALL YNAME('CP$',100)
C    DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
```

```
        CALL AREA2D(6.0,8.0)
C     DEFINE HEADING LABEL
        CALL HEADIN('CP DISTRIBUTION$',-100,2.,1)
C     PLOT ADDITIONAL TICK MARKS
        CALL XTICKS(1)
        CALL YTICKS(1)
C     PACK LEGEND LABELS INTO ARRAY IPACK
        CALL LINES(L1,IPACK,1)
C     SET UP AXIS
        CALL GRAF(0.0,0.2,1.0,(MIN-.1),((MAX-MIN)/5.),(MAX+.1))
C     FRAME THE SUBPLOT AREA
        CALL FRAME
C     PLOT PRESSURE DISTRIBUTION DATA WITH A THICK LINE AND MARKER 15
        CALL MARKER(15)
        CALL THKCRV(.04)
        CALL CURVE(XX,CP,NUM,1)
C     PRINT MESSAGES
        IF (NFLAG.EQ.1)GO TO 58
          CALL MESSAG('NACA AIRFOIL $',100,2.,7.0)
          CALL INTNO(NACA,'ABUT','ABUT')
   58   CALL MESSAG('NUMBER OF PANELS USED = $',100,2.,6.5)
        CALL INTNO(NUMPTS,'ABUT','ABUT')
        CALL MESSAG('ANGLE OF ATTACK = $',100,2.,6.0)
        CALL REALNO(AIR,2,4.75,6.0)
C     CHANGE LEGEND NAME TO "CP DISTRIBUTION"
        CALL MYLEGN('CP DISTRIBUTION$',100)
C     PLOT LEGEND
        CALL LEGEND(IPACK,1,.75,.5)
C     END PLOT
        CALL ENDPL(0)
C     CREATE GRAPHICS METAFILE P1.UIS
        CALL METAFL(1)
C     TERMINATE PLOT AT END OF PLOTTING SESSION
        CALL DONEPL
        RETURN
        END

       SUBROUTINE GRAF2
C
C     DEFINE IPACK ARRAY FOR LEGEND
       INTEGER*4 IPACK(35)
       INTEGER NUMERAL,FIGURE
       REAL XX(101),YY(101),MAX,MIN
       CHARACTER*40 L1
       COMMON /LEROY/NUMERAL
       COMMON /BOD/ NODTOT,COSTHE(100),SINTHE(100),NFLAG
       COMMON /BRAVO/NUMPTS
       COMMON /PAR/ NACA,TAU,EPSMAX,PTMAX
       COMMON /CHARLIE/AIR
       COMMON /PIN/XX,YY
       COMMON /FLAGGER/FIGURE
C     READ ELEMENTS OF UNIT 15 INTO ARRAYS TO PLOT
        OPEN(UNIT=15,FILE='BODYSHAPE.DAT',STATUS='OLD')
        IF (FIGURE.EQ.2)GO TO 31
        XX(1) = 0.0
        YY(1) = 0.0
        DO 30 I = 2,NUMERAL+1
          READ (15,*) XX(I),YY(I)
  30     CONTINUE
        XX(NUMERAL+2) = 1.0
        YY(NUMERAL+2) = 0.0
        NUMERAL = NUMERAL + 2
  31    IF (FIGURE.EQ.2)THEN
        READ (15,*) XERR,YERR
        DO I = 1,NUMERAL-2
          READ (15,*) XX(I),YY(I)
        END DO
        ENDIF
        CLOSE(UNIT=15)
C     CALL SCALER TO FIND THE MAX AND MIN VALUES OF THE Y ORDINATE ARRAY
        CALL FORM2(MAX,MIN)
C     DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
        L1 = 'AIRFOIL SHAPE$'
C     INITIALIZE THE GRAPHICS SYSTEM
        CALL INIT
C     LABEL X AND Y AXES USING SELF COUNTING STRINGS
        CALL XNAME('X$',100)
        CALL YNAME('Y$',100)
C     DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
        CALL AREA2D(6.0,8.0)
C     DEFINE HEADING LABEL
        CALL HEADIN('BODY SHAPE$',-100,2.,1)
C     PLOT ADDITIONAL TICK MARKS
        CALL XTICKS(1)
        CALL YTICKS(1)
C     PACK LEGEND LABELS INTO ARRAY IPACK
        CALL LINES(L1,IPACK,1)
C     SET UP AXIS
        CALL GRAF(0.0,0.2,1.0,-.5,.2,.5)
C     FRAME THE SUBPLOT AREA
        CALL FRAME
C     PLOT PRESSURE DISTRIBUTION DATA WITH A THICK LINE AND MARKER 15
        CALL MARKER(15)
        CALL THKCRV(.04)
        CALL CURVE(XX,YY,NUMERAL,1)
C     PRINT MESSAGES
        IF (NFLAG.EQ.1)GO TO 58
          CALL MESSAG('NACA AIRFOIL $',100,2.,7.0)
          CALL INTNO(NACA,'ABUT','ABUT')
  58    CALL MESSAG('NUMBER OF PANELS USED = $',100,2.,6.5)
        CALL INTNO(NUMPTS,'ABUT','ABUT')
        CALL MESSAG('ANGLE OF ATTACK = $',100,2.,6.0)
        CALL REALNO(AIR,2,4.75,6.0)
C     CHANGE LEGEND NAME TO "UPPER AND LOWER SURFACES"
        CALL MYLEGN('UPPER SURFACE AND LOWER SURFACES$',100)
C     PLOT LEGEND
        CALL LEGEND(IPACK,1,.75,1.0)
C     END PLOT
        CALL ENDPL(0)
C     CREATE GRAPHICS METAFILE P2.UIS
        CALL METAFL(2)
C     TERMINATE PLOT AT END OF PLOTTING SESSION
```

```
      CALL DONEPL
      RETURN
      END

     SUBROUTINE GRAF3
C
C    DEFINE IPACK ARRAY FOR LEGEND
     INTEGER*4 IPACK(35)
     REAL ANGLE(13),CLA(13),CMA(13),MAX,MIN
     CHARACTER*40 L1,L2,L3
     COMMON /PEN/ CLA,CMA,ANGLE
     COMMON /BOD/ NODTOT,COSTHE(100),SINTHE(100),NFLAG
     COMMON /BRAVO/NUMPTS
     COMMON /PAR/ NACA,TAU,EPSMAX,PTMAX
     DIMENSION Y(3),X(3)
     CALL  MAXMIN(CLA,13,MAX,MIN)
     CALL MAXMIN(CMA,13,VALMAX,VALMIN)
C    DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
      L1 = 'CL VS. ANGLE OF ATTACK$'
      L2 = 'CM C/4 VS.ANGLE OF ATTACK$'
      L3 = 'ZERO LINE-REFERENCE ONLY$'
C    INITIALIZE THE GRAPHICS SYSTEM
      CALL INIT
C    LABEL X AND Y AXES USING SELF COUNTING STRINGS
      CALL XNAME('ANGLE OF ATTACK$',100)
      CALL YNAME('MOMENT(C/4) & LIFT COEFFICIENTS$',100)
C    DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
      CALL AREA2D(6.0,8.0)
C    DEFINE HEADING LABEL
      CALL HEADIN('CL & CM C/4 VS. ALPHA$',-100,2.,1)
C    PLOT ADDITIONAL TICK MARKS
      CALL XTICKS(1)
      CALL YTICKS(1)
C    PACK LEGEND LABELS INTO ARRAY IPACK
      CALL LINES(L1,IPACK,1)
      CALL LINES(L2,IPACK,2)
      CALL LINES(L3,IPACK,3)
C    SET UP AXIS
      CALL GRAF(-8.,4.,16.,(MIN-.5),((MAX-MIN)/5.),(MAX+.5))
C    FRAME THE SUBPLOT AREA
      CALL FRAME
C    PLOT DATA WITH A THICK LINE AND MARKER 15
      CALL MARKER(15)
      CALL THKCRV(.04)
      CALL CURVE(ANGLE,CLA,13,1)
      CALL MARKER(16)
      CALL RESET('THKCRV')
      CALL DASH
      CALL CURVE(ANGLE,CMA,13,1)
C  ZERO LINE - REFERENCE ONLY
      X(1) = -8.
      X(2) =  2.
      X(3) = 15.9
      Y(1)  = 0.
      Y(2)  = 0.
      Y(3)  = 0.
```

```
        CALL MARKER(17)
        CALL RESET('THKCRV')
        CALL DOT
        CALL CURVE(X,Y,3,1)
C     PRINT MESSAGES
        IF (NFLAG.EQ.1)GO TO 58
          CALL MESSAG('NACA AIRFOIL $',100,1.5,8.7)
          CALL INTNO(NACA,'ABUT','ABUT')
  58    CALL MESSAG('NUMBER OF PANELS USED = $',100,1.5,8.3)
        CALL INTNO(NUMPTS,'ABUT','ABUT')
C     CHANGE LEGEND NAME TO " "
        CALL MYLEGN('  $',100)
C     PLOT LEGEND
        CALL LEGEND(IPACK,1,.75,6.5)
C     END PLOT
        CALL ENDPL(0)
C     CREATE GRAPHICS METAFILE P3.UIS
        CALL METAFL(3)
C     TERMINATE PLOT AT END OF PLOTTING SESSION
        CALL DONEPL
        RETURN
        END

       SUBROUTINE GRAF4
C
C     DEFINE IPACK ARRAY FOR LEGEND
       INTEGER*4 IPACK(35)
       REAL ANGLE(13),CLA(13),CMA(13),MAX,MIN
       CHARACTER*40 L1
       COMMON /PEN/ CLA,CMA,ANGLE
       COMMON /BRAVO/NUMPTS
       COMMON /PAR/ NACA,TAU,EPSMAX,PTMAX
        CALL  MAXMIN(CMA,13,MAX,MIN)
C     DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
        L1 = 'CM C/4 VS. ANGLE OF ATTACK$'
C     INITIALIZE THE GRAPHICS SYSTEM
        CALL INIT
C     LABEL X AND Y AXES USING SELF COUNTING STRINGS
        CALL XNAME('ANGLE OF ATTACK$',100)
        CALL YNAME('MOMENT COEFFICIENT (C/4) $',100)
C     DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
        CALL AREA2D(6.0,8.0)
C     DEFINE HEADING LABEL
        CALL HEADIN('CM C/4 VS. ALPHA$',-100,2.,1)
C     PLOT ADDITIONAL TICK MARKS
        CALL XTICKS(1)
        CALL YTICKS(1)
C     PACK LEGEND LABELS INTO ARRAY IPACK
        CALL LINES(L1,IPACK,1)
C     SET UP AXIS
        CALL GRAF(-10.,4.,18.,(MIN-.01),((MAX-MIN)/2.),(MAX+.01))
C     FRAME THE SUBPLOT AREA
        CALL FRAME
C     PLOT PRESSURE DISTRIBUTION DATA WITH A THICK LINE AND MARKER 15
        CALL MARKER(15)
        CALL THKCRV(.04)
        CALL CURVE(ANGLE,CMA,13,1)
C     PRINT MESSAGES
        IF (NFLAG.EQ.1)GO TO 58
          CALL MESSAG('NACA AIRFOIL $',100,2.,7.0)
          CALL INTNO(NACA,'ABUT','ABUT')
  58    CALL MESSAG('NUMBER OF PANELS USED = $',100,2.,6.5)
        CALL INTNO(NUMPTS,'ABUT','ABUT')
C     CHANGE LEGEND NAME TO " "
        CALL MYLEGN('  $',100)
C     PLOT LEGEND
        CALL LEGEND(IPACK,1,.75,.5)
C     END PLOT
        CALL ENDPL(0)
C     CREATE GRAPHICS METAFILE P4.UIS
        CALL METAFL(4)
C     TERMINATE PLOT AT END OF PLOTTING SESSION
        CALL DONEPL
        RETURN
        END

       SUBROUTINE GRAF5
C
C     DEFINE IPACK ARRAY FOR LEGEND
       INTEGER*4 IPACK(35)
       REAL ANGLE(13),CLA(13),CMA(13),CMB(13),MAX,MIN
       CHARACTER*40 L1
       COMMON /PEN/ CLA,CMA,ANGLE,CMB
       COMMON /BRAVO/NUMPTS
       COMMON /PAR/ NACA,TAU,EPSMAX,PTMAX
        CALL  MAXMIN(CMB,13,MAX,MIN)
C     DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
        L1 = 'CM VS. ANGLE OF ATTACK$'
C     INITIALIZE THE GRAPHICS SYSTEM
        CALL INIT
C     LABEL X AND Y AXES USING SELF COUNTING STRINGS
        CALL XNAME('ANGLE OF ATTACK$',100)
        CALL YNAME('MOMENT COEFFICIENT$',100)
C     DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
        CALL AREA2D(6.0,8.0)
C     DEFINE HEADING LABEL
        CALL HEADIN('CM VS. ALPHA$',-100,2.,1)
C     PLOT ADDITIONAL TICK MARKS
        CALL XTICKS(1)
        CALL YTICKS(1)
C     PACK LEGEND LABELS INTO ARRAY IPACK
        CALL LINES(L1,IPACK,1)
C     SET UP AXIS
        CALL GRAF(-10.,4.,18.,(MIN-.2),.2,(MAX+.2))
C     FRAME THE SUBPLOT AREA
        CALL FRAME
C     PLOT PRESSURE DISTRIBUTION DATA WITH A THICK LINE AND MARKER 15
        CALL MARKER(15)
        CALL THKCRV(.04)
        CALL CURVE(ANGLE,CMB,13,1)
C     PRINT MESSAGES
        IF (NFLAG.EQ.1)GO TO 58
```

```
          CALL MESSAG('NACA AIRFOIL $',100,2.,7.0)
          CALL INTNO(NACA,'ABUT','ABUT')
  58    CALL MESSAG('NUMBER OF PANELS USED = $',100,2.,6.5)
        CALL INTNO(NUMPTS,'ABUT','ABUT')
C     CHANGE LEGEND NAME TO " "
        CALL MYLEGN('  $',100)
C     PLOT LEGEND
        CALL LEGEND(IPACK,1,.75,.5)
C     END PLOT
        CALL ENDPL(0)
C     CREATE GRAPHICS METAFILE P5.UIS
        CALL METAFL(5)
C     TERMINATE PLOT AT END OF PLOTTING SESSION
        CALL DONEPL
        RETURN
        END

       SUBROUTINE INDATA(X,Y,N,NLOWER,NUPPER)
C
C                   SET PARAMETERS OF BODY SHAPE
C                   FLOW SITUATION, AND NODE DISTRIBUTION
C
C                   USER MUST INPUT
C                        NLOWER = NUMBER OF NODES ON LOWER SURFACE
C                        NUPPER = NUMBER OF NODES ON UPPER SURFACE
C                   PLUS DATA ON BODY AND SUBROUTINE BODY
C
       REAL X(N),Y(N)
       INTEGER NUMPTS,I,STATUS,IFLAG
       CHARACTER*20 INFILE
       INTEGER*2 INFILE_SIZE
       INTEGER FLAG,INFIS
       LOGICAL  EXIST
       COMMON /FINAL/FLAG,XREF,YCORD
       COMMON /BOD/ NODTOT,COSTHE(100),SINTHE(100),NFLAG
       COMMON /BRAVO/NUMPTS
       COMMON /CHARLIE/NO
       COMMON /PAR/ NACA,TAU,EPSMAX,PTMAX
       DIMENSION XREF(101),YCORD(101),Y1(101),X1(101),Y2(101)
      +,X2(101)
       IF (FLAG.EQ.2)THEN
          NUPPER=NUMPTS/2
          NLOWER=NUMPTS/2
          GO TO 909
       ENDIF
C   CALL LIBRARY ROUTINE TO CLEAR THE SCREEN, THEN PRINT HEADER
     5 CALL CLRSCRN
       PRINT *
       PRINT *
       PRINT *, '                PROGRAM PANEL  '
       PRINT *
       PRINT *, '     SMITH-HESS (DOUGLAS) PANEL METHOD'
       PRINT *, '     FOR A SINGLE-ELEMENT LIFTING AIRFOIL'
       PRINT *, '     IN TWO-DIMENSIONAL INCOMPRESSIBLE FLOW'
       PRINT *
       PRINT *, ' DO YOU WISH TO:    '
      PRINT *, '      1) USE AIRFOIL SURFACE COORDINATE DATA VALUES.'
      PRINT *, '      2) HAVE COMPUTER GENERATE AN APPROXIMATION'
      PRINT *, '         FOR A NACA XXXX OR 230XX AIRFOIL SECTION.'
      PRINT *, '      3) QUIT THE PROGRAM.'
      PRINT *, ' ENTER 1, 2, OR 3'
      READ (5,*)  NFLAG
      GO TO (10,50,999) NFLAG
C **** ROUTINE TO INPUT SHAPE FROM DATA FILE, KEYBOARD OR DATA STMTS **
   10 CALL CLRSCRN
      PRINT *
      PRINT *, ' DO YOU WISH TO ENTER THE SURFACE COORDINATE VALUES: '
      PRINT *, '      1) FROM A DATA FILE.'
      PRINT *, '      2) FROM THE KEYBOARD.'
      PRINT *, '      3) USING DATA STATEMENTS ALREADY ENTERED'
      PRINT *, '         IN THE MAIN PROGRAM. ** NOTE ** THIS REQUIRES'
      PRINT *, '         THAT PROGRAM BE MODIFIED IN ADVANCE BY MOVING'
      PRINT *, '         DATA STATEMENTS TO THE CORRECT LOCATION.'
      PRINT *, ' ENTER 1, 2, OR 3.  (FOR PREVIOUS MENU ENTER 4)'
   12 READ (5,*)  IFLAG
      IF (IFLAG .EQ. 4) GO TO 5
      IF (IFLAG .LT. 1 .OR. IFLAG .GT. 3)  THEN
          PRINT *, 'INVALID ENTRY. ENTER 1, 2, OR 3.'
          GO TO 12
      END IF
      IF (IFLAG .EQ. 1) GO TO 110
      IF (IFLAG .EQ. 3) THEN
         NUMPTS=28
         GO TO 100
      ENDIF
****  CUE THE USER TO ENTER THE NUMBER OF DATA POINTS (NUMPTS)
   15 CALL CLRSCRN
      PRINT *
      PRINT *, 'ENTER NUMBER OF DATA POINTS'
      READ *, NUMPTS
****  ECHO CHECK THE INPUT
      PRINT *,'NUMBER OF DATA POINTS TO BE ENTERED =',NUMPTS
      PRINT *
      PRINT *,'IS THIS VALUE CORRECT? (YES=1, NO=2)'
      READ *, M1
      IF (M1 .GT. 1) GO TO 15
      CALL NODES(NUMPTS,NLOWER,NUPPER)
C **** SEND CONTROL TO DATA FILE OR KEYBOARD ENTRY ROUTINE ****
  110 GO TO (20,30,100) IFLAG
C *** DATA FILE READ ROUTINE
C
C   LIB$GET_INPUT IS A VAX LIBRARY ROUTINE.  IT MAY BE REPLACED BY AN
C   EQUIVALENT WRITE/READ TO GET THE FILENAME INTO THE PROGRAM.
C
   20 PRINT *, ' '
      PRINT *, ' NOTICE--YOU CAN NOW ENTER ANY FILE NAME,'
      PRINT *, '          NOT JUST "INFILE.DAT"'
      PRINT *, ' '
      STATUS = LIB$GET_INPUT (INFILE,          | THE INPUT FILE
     2       ' ENTER THE DATA FILE NAME:  ',   | PROMPT
     2                        INFILE_SIZE)     | FILENAME SIZE
C  CHECK TO SEE IF THE FILE EXISTS BEFORE TRYING TO ACCESS IT
```

```
      IF (INFILE .EQ. '999') GO TO 5
      INQUIRE (FILE = INFILE (1:INFILE_SIZE), EXIST = EXIST)
      IF (.NOT. EXIST) THEN
         PRINT *
         PRINT *, ' THAT FILE NAME DOES NOT EXIST.'
         PRINT *, ' (ENTER 999 TO RETURN TO MENU).'
         PRINT *
         GO TO 20
      END IF
C OPEN FILE FOR SURFACE COORDINATE INPUT
      OPEN (UNIT=13,
     2      FILE= INFILE,
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2      STATUS= 'OLD')
      PRINT *, ' '
      PRINT *, ' HOW MANY DATA POINTS ARE IN YOUR INPUT FILE?'
      PRINT *, ' '
      READ *, INFIS
      NUMPTS = INFIS
C     PRINT *, INFILE_SIZE
      DO 25   I = 1,INFIS
          READ (13,*) X(I),Y(I)
      PRINT 1010, X(I),Y(I)
   25 CONTINUE
 1010 FORMAT(F10.4,F10.4)
      GO TO 100
C **** ROUTINE TO ENTER DATA FROM THE KEYBOARD *****
   30 CALL INPUT(X,Y,NUMPTS)
      GO TO 100
C **** ROUTINE TO CALCULATE SHAPE, GIVEN NACA NUMBER *****
   50 CALL CLRSCRN
      PRINT *
      PRINT *, '  ENTER NUMBER OF SURFACE DATA POINTS DESIRED'
      READ *, NUMPTS
****  ECHO CHECK THE INPUT
      CALL CLRSCRN
      PRINT *
      PRINT *,'  NUMBER OF SURFACE DATA POINTS TO BE GENERATED =',NUMPTS
      PRINT *
      PRINT *,'  IS THIS VALUE CORRECT? (YES=1, NO=2)'
      READ *, M1
      IF (M1 .GT. 1) GO TO 50
      CALL NODES(NUMPTS,NLOWFR,NUPPER)
      PRINT *
      PRINT *, '  INPUT NACA NUMBER, ANY FOUR-DIGIT OR 230XX SERIES'
      READ (5,*) NACA
      IEPS    = NACA/1000
      IPTMAX  = NACA/100 - 10*IEPS
      ITAU    = NACA - 1000*IEPS - 100*IPTMAX
      EPSMAX  = IEPS*0.01
      PTMAX   = IPTMAX*0.1
      TAU     = ITAU*0.01
      IF (IEPS .LT. 10) RETURN
      PTMAX   = 0.2025
      EPSMAX  = 2.6595*PTMAX**3
  909 IF (FLAG.EQ.2) THEN
C     PRINT *, NUMPTS
C CHECK DATA
C      OPEN(UNIT=69,FILE='TIM.DAT',STATUS='NEW')
C      DO I = 1,NUMPTS
C        WRITE(69,978)XREF(I),YCORD(I)
C 978    FORMAT(1X,F8.4,F12.6)
C      END DO
      X(1)=1.
      Y(1)=0.
      DO I= 2,NUMPTS+1
        DUMMY = XREF(I)
        DUM   = YCORD(I)
        X(I) =DUMMY
        Y(I) =DUM
      END DO
      DO I = 1,INT(NUMPTS/2)+1
        UUU=X(I)
        VVV=Y(I)
        X1(I)=UUU
        Y1(I)=VVV
      END DO
      CALL SORTER(X1,Y1,INT(NUMPTS/2)+1)
      DO I = INT(NUMPTS/2)+1,NUMPTS+1
        UUU=X(I)
        VVV=Y(I)
        X2(I)=UUU
        Y2(I)=VVV
      END DO
      CALL SORTER(X2,Y2,NUMPTS/2+1)
      DO I=1,INT(NUMPTS/2)+1
        DDD=X1(I)
        X(I)=DDD
        EEE=Y1(I)
        Y(I)=EEE
      END DO
      DO I=INT(NUMPTS/2)+2,NUMPTS+1
        DDD=X2(I)
        X(I)=DDD
        EEE=Y2(I)
        Y(I)=EEE
      END DO
      NUMPTS = NUMPTS+1
      N = NUMPTS
      ENDIF
  100 RETURN
  999 STOP
      END

      SUBROUTINE INPUT(A,B,N)
C
      INTEGER N,I
      DIMENSION A(N), B(N)
C     CUE THE USER TO INPUT X VALUES
```

```
   10  PRINT *, 'ENTER X VALUES AS MANY PER LINE AS DESIRED'
       READ *, (A(I), I = 1,N)
C      ECHO CHECK THE INPUT
       PRINT 20, N
   20  FORMAT (/1X,'TABLE OF', I3,' X VALUES:'/1X,21('='))
       PRINT 30, (A(I), I=1,N)
   30  FORMAT (1X,3F10.6)
       PRINT *,'ARE THE VALUES CORRECT? (YES=1, NO=2)'
       READ *, J1
       IF (J1 .GT. 1) GO TO 10
C      CUE THE USER TO INPUT Y VALUES
   35  PRINT *,'ENTER Y VALUES AS MANY PER LINE AS DESIRED'
       READ *, (B(J), J=1,N)
C      ECHO CHECK THE INPUT
       PRINT 40, N
   40  FORMAT (/1X,'TABLE OF', I3,' Y VALUES:'/1X,21('='))
       PRINT 30, (B(J), J=1,N)
       PRINT *,'ARE THE VALUES CORRECT? (YES=1, NO=2)'
       READ *, K1
       IF (K1 .GT. 1) GO TO 35
       RETURN
       END

       SUBROUTINE  MAXMIN(ARRAY,NY,VALMAX,VALMIN)
C
C   ARRAY = THE ARRAY WHICH IS BEING SORTED INTO ASCENDING ORDER
C   NUMBER= THE NUMBER OF ELEMENTS IN THE ARRAY TO BE SORTED
C   VALMAX= LARGEST VALUE IN THE ARRAY
C   VALMIN= SMALLEST VALUE IN THE ARRAY
       REAL VALMAX,VALMIN
       INTEGER NUMBER
       LOGICAL SORTED
       DIMENSION ARRAY(100)
       SORTED = .FALSE.
       NUMBER = NY
   30  IF (.NOT.SORTED) THEN
          SORTED = .TRUE.
          DO 40 I = 1,NUMBER - 1
            IF(ARRAY(I).GT.ARRAY(I+1))THEN
              VALUE = ARRAY(I)
              ARRAY(I) = ARRAY(I+1)
              ARRAY(I+1) = VALUE
              SORTED = .FALSE.
            ENDIF
   40     CONTINUE
          GO TO 30
       ENDIF
       VALMAX = ARRAY(NUMBER)
       VALMIN = ARRAY(1)
       RETURN
       END

       SUBROUTINE NODES(NUMPTS,NLOWER,NUPPER)
C
C **** CALCULATE NLOWER AND NUPPER FOR LATER USE ***
       PRINT *
```

```
      PRINT *,'  ARE THE NUMBER OF UPPER AND LOWER SURFACE'
      PRINT *,'  DATA POINTS(NODES) EQUAL? (YES=1, NO=2)'
      READ *, M1
      IF (M1 .EQ. 1) THEN
          NLOWER = NUMPTS/2
          NUPPER = NLOWER
      ELSE
          CALL CLRSCRN
          PRINT *
          PRINT *, ' TOTAL NUMBER OF SURFACE POINTS =', NUMPTS
   20     PRINT *, '-------------------------------------------'
          PRINT *
          PRINT *, ' INPUT NUMBER OF LOWER SURFACE POINTS, NLOWER'
          READ (5,*)   NLOWER
          PRINT *, ' INPUT NUMBER OF UPPER SURFACE POINTS, NUPPER'
          READ (5,*)   NUPPER
          NTEST = NLOWER + NUPPER
          IF (NTEST .NE. NUMPTS) THEN
           PRINT *, '  OKAY, TRY IT AGAIN EINSTEIN.  REMEMBER ADDITION?'
           PRINT *, '  NLOWER + NUPPER MUST EQUAL',NUMPTS
             GO TO 20
          END IF
      END IF
      RETURN
      END

      SUBROUTINE OUTPUT
C
      COMMON /BLCO/ RL,NBL(2),XCTRI(2)
      COMMON /BLC2/ NX,NXT,NP,NPT,NTR,IT,ISF
      COMMON /BLC3/ X(100),UE(100),P1(100),P2(100),GMTR(100)
      COMMON /BLC7/ ETA(101),DETA(101),A(101)
      COMMON /BLC8/ F(101,2),U(101,2),V(101,2),B(101,2)
      COMMON /BLCS/ DLS(100),VW(100),CF(100),THT(100)
C
      IF (NX.EQ.1) THEN
        DLS(NX) = 0.
        THT(NX) = 0.
        CF(NX)  = 0.
        VW(NX)  = V(1,2)
      ELSE
        SQRX    = SQRT(UE(NX)*X(NX)*RL)
        CF(NX)  = 2. * V(1,2) * B(1,2) /SQRX
        VW(NX)  = V(1,2)
        DLS(NX) = X(NX)/SQRX * (ETA(NP)-F(NP,2))
        U1      = U(1,2) * (1.-U(1,2))
        SUM     = 0.
        DO 20 J = 2,NP
          U2    = U(J,2) * (1.  - U(J,2))
          SUM   = SUM + A(J) * (U1 + U2)
          U1    =U2
   20 CONTINUE
      THT(NX) = X(NX)/SQRX * SUM
      ENDIF
C
```

```
C     SHIFT PROFILES FOR THE NEXT STATION
C
      DO 175 J = 1,NPT
        F(J,1) = F(J,2)
        U(J,1) = U(J,2)
        V(J,1) = V(J,2)
        B(J,1) = B(J,2)
  175 CONTINUE
C
      RETURN
      END

      SUBROUTINE SETUP(X,Y,N,NLOWER,NUPPER)
C
      REAL X(N),Y(N)
      REAL PI
      INTEGER FIGURE
      COMMON /BOD/ NODTOT,COSTHE(100),SINTHE(100),NFLAG
      COMMON /NUM/ PI,PI2INV
      COMMON /LEROY/NUMERAL
      COMMON /FLAGGER/FIGURE
      COMMON /BRAVO/NUMPTS
      DIMENSION XE(100),YE(100)
      DATA PI/3.1415926585/
      PI2INV  = 1./(2. * PI)
C     NZERO   = 31
C     YMULT   = 200
C
C             SET COORDINATES OF NODES ON BODY SURFACE
C
C      IF(FIGURE.EQ.2)THEN
C         OPEN(UNIT=43,FILE='ME1.DAT',STATUS='OLD')
C         READ(43,999)XERR,YERR
C         DO I = 1,NUMPTS-2
C            PRINT *, NUMPTS
C            READ(43,999)XE(I),YE(I)
C            CAM=XE(I)
C            CAN=YE(I)
C            X(I)=CAM
C            Y(I)=CAN
C         END DO
C         CLOSE(UNIT=43)
C      ENDIF
      WRITE (11,1000)
      NPOINT  = NLOWER
      SIGN = -1.
      NSTART  = 0
      DO 110  NSURF = 1,2
      DO 100  N = 1,NPOINT
      FRACT   = FLOAT(N-1)/FLOAT(NPOINT)
      Z       = .5*(1.  - COS(PI*FRACT))
      I       = NSTART + N
C
      IF (NFLAG .EQ. 1.OR.FIGURE.EQ.2) GO TO 90
      CALL BODY(Z,SIGN,X(I),Y(I))
 90   WRITE (11,1010) X(I),Y(I)
```

```
      WRITE (15,1010) X(I),Y(I)
C     PRINT 1010, X(I),Y(I)
 100  CONTINUE
      NPOINT = NUPPER
      SIGN   = 1.0
      NSTART = NLOWER
 110  CONTINUE
      NUMERAL = NPOINT*2
      NODTOT  = NLOWER + NUPPER
      X(NODTOT+1) = X(1)
      Y(NODTOT+1) = Y(1)
C
C             SET SLOPES OF PANELS
C
      DO 200  I = 1,NODTOT
      DX        = X(I+1) - X(I)
      DY        = Y(I+1) - Y(I)
      DIST      = SQRT(DX*DX +DY*DY)
      SINTHE(I)     = DY/DIST
      COSTHE(I)     = DX/DIST
  200 CONTINUE
  999 FORMAT(1X,F8.4,2X,F8.4)
 1000 FORMAT(/////,11X,' BODY SHAPE',//,12X,'X',9X,'Y',/)
 1010 FORMAT(5X,F10.4,F10.4)
      RETURN
      END

      SUBROUTINE SOLV3
C
      COMMON /BLC2/ NX,NXT,NP,NPT,NTR,IT,ISF
      COMMON /BLC7/ ETA(101),DETA(101),A(101)
      COMMON /BLC8/ F(101,2),U(101,2),V(101,2),B(101,2)
      COMMON /BLC9/ S1(101),S2(101),S3(101),S4(101),S5(101),
     +S6(101),S7(101),S8(101),R1(101),R2(101),R3(101),R4(101)
      COMMON /BLC6/ DELF(101),DELU(101),DELV(101)
      DIMENSION A11(101),A12(101),A13(101),A14(101),
     +          A21(101),A22(101),A23(101),A24(101)
      A11(1) = 1.
      A12(1) = 0.
      A13(1) = 0.
      A21(1) = 0.
      A22(1) = 1.
      A23(1) = 0.
      G11    =-1.
      G12    =-A(2)
      G13    = 0.
      G21    = S4(2)
      G23    =-S2(2)/A(2)
      G22    = G23 + S6(2)
      A11(2) = 1.
      A12(2) =-A(2) - G13
      A13(2) = A(2) * G13
      A21(2) = S3(2)
      A22(2) = S5(2) - G23
      A23(2) = S1(2) + A(2) * G23
      R1(2)  = R1(2) - (G11*R1(1)+G12*R2(1)+G13*R3(1))
      R2(2)  = R2(2) - (G21*R1(1)+G22*R2(1)+G23*R3(1))
C
C     FORWARD SWEEP
C
      DO 500 J=2,NP
        DEN  = (A13(J-1)*A21(J-1)-A23(J-1)*A11(J-1)-A(J)*
     +        (A12(J-1)*A21(J-1)-A22(J-1)*A11(J-1)))
      DEN1 = A22(J-1)*A(J)-A23(J-1)
      G11  = (A23(J-1)+A(J)*(A(J)*A21(J-1)-A22(J-1)))/DEN
      G12  = -(A(J)*A(J)+G11*(A12(J-1)*A(J)-A13(J-1)))/DEN1
      G13  = (G11*A13(J-1)+G12*A23(J-1))/A(J)
C        PRINT *, S2(J)
C        PRINT *, A21(J-1)
C        PRINT *, A(J)
C        PRINT *, S4(J)
C        PRINT *, A22(J-1)
C        PRINT *, S6(J)
C        PRINT *, A21(J-1)
C        PRINT *, DEN
C        PRINT *, NP
C        PRINT *, J
      G21  = (S2(J)*A21(J-1)-S4(J)*A23(J-1)+A(J)*(S4(J)*
     +       A22(J-1)-S6(J)*A21(J-1)))/DEN
      G22  = (-S2(J)+S6(J)*A(J)-G21*(A(J)*A12(J-1)-
     +       A13(J-1)))/DEN1
        G23  = G21*A12(J-1)+G22*A22(J-1)-S6(J)
      A11(J) = 1.
      A12(J) = -A(J)-G13
      A13(J) = A(J)*G13
        A21(J) = S3(J)
        A22(J) = S5(J) - G23
        A23(J) = S1(J) + A(J) * G23
      R1(J)  = R1(J)- (G11*R1(J-1)+G12*R2(J-1)+G13*R3(J-1))
        R2(J)  = R2(J)- (G21*R1(J-1)+G22*R2(J-1)+G23*R3(J-1))
  500 CONTINUE
C
C     BACKWARD SWEEP
C
        DELU(NP)  = R3(NP)
      E1        = R1(NP) - A12(NP)*DELU(NP)
        E2        = R2(NP) - A22(NP)*DELU(NP)
        DELV(NP)  = (E2*A11(NP)-E1*A21(NP))/(A23(NP)*A11(NP)-
     +A13(NP)*A21(NP))
      DELF(NP)  = (E1-A13(NP)*DELV(NP))/A11(NP)
       DO 600 J = NP-1,1,-1
      E3 = R3(J)-DELU(J+1)+A(J+1)*DELV(J+1)
      DEN2 = A21(J)*A12(J)*A(J+1)-A21(J)*A13(J)-A(J+1)*
     +A22(J)*A11(J)+A23(J)*A11(J)
      DELV(J) = (A11(J)*(R2(J)+E3*A22(J))-A21(J)*R1(J)-
     +E3*A21(J)*A12(J))/DEN2
      DELU(J) = -A(J+1) * DELV(J) - E3
      DELF(J) = (R1(J)-A12(J)*DELU(J)-A13(J)*DELV(J))/A11(J)
  600 CONTINUE
C
       DO 700 J = 1,NP
      F(J,2) = F(J,2) + DELF(J)
      U(J,2) = U(J,2) + DELU(J)
          V(J,2) = V(J,2) + DELV(J)
  700 CONTINUE
      U(1,2) = 0.
C
      RETURN
      END

        SUBROUTINE  SORTER(ARRAY,CARRY,NY)
C
C  ARRAY = THE ARRAY WHICH IS BEING SORTED INTO ASCENDING ORDER
C  CARRY = THE ARRAY VARIABLES STAYING WITH EACH RESP. ARRAY VAR. ABOVE
C  NY    = THE NUMBER OF ELEMENTS IN THE ARRAY TO BE SORTED
        LOGICAL SORTED
        DIMENSION ARRAY(101),CARRY(101)
        SORTED = .FALSE.
        NUMBER = NY
  30    IF (.NOT.SORTED) THEN
           SORTED = .TRUE.
           DO 40 I = 1,NUMBER - 1
             IF(ARRAY(I).LT.ARRAY(I+1))THEN
               VALUE = ARRAY(I)
               VAL   = CARRY(I)
               ARRAY(I) = ARRAY(I+1)
               CARRY(I) = CARRY(I+1)
               ARRAY(I+1) = VALUE
               CARRY(I+1) = VAL
               SORTED = .FALSE.
             ENDIF
  40       CONTINUE
           GO TO 30
        ENDIF
        RETURN
        END

        SUBROUTINE  SORTNUM(ARRAY,CARRY,NY)
C
C  ARRAY = THE ARRAY WHICH IS BEING SORTED INTO ASCENDING ORDER
C  CARRY = THE ARRAY VARIABLES STAYING WITH EACH RESP. ARRAY VAR. ABOVE
C  NY    = THE NUMBER OF ELEMENTS IN THE ARRAY TO BE SORTED
        LOGICAL SORTED
        DIMENSION ARRAY(101),CARRY(101)
        SORTED = .FALSE.
        NUMBER = NY
  30    IF (.NOT.SORTED) THEN
           SORTED = .TRUE.
           DO 40 I = 1,NUMBER - 1
             IF(ARRAY(I).GT.ARRAY(I+1))THEN
               VALUE = ARRAY(I)
               VAL   = CARRY(I)
               ARRAY(I) = ARRAY(I+1)
               CARRY(I) = CARRY(I+1)
               ARRAY(I+1) = VALUE
               CARRY(I+1) = VAL
               SORTED = .FALSE.
             ENDIF
  40     CONTINUE
         GO TO 30
      ENDIF
      RETURN
      END

      SUBROUTINE SPEVAL(N,COORX,COORY,FDP,XX,F)
C
C     THIS SUBROUTINE EVALUATES THE CUBIC SPLINE GIVEN
C     THE DERIVATIVES COMPUTED  BY SUBROUTINE SPLINE.
C     THE INPUT PARAMETERS N,X,Y,FDP HAVE THE SAME
C     MEANING AS IN SPLINE.
C     XX = VALUE OF INDEPENDENT VARIABLE FOR WHICH
C          AN INTERPOLATED VALUE IS REQUESTED
C     F  = THE INTERPOLATED RESULT
      DIMENSION COORX(101),COORY(101),FDP(101)
C     THE FIRST STEP IS TO FIND THE PROPER INTERVAL
      NM1 = N -1
      DO 1 I=1,NM1
      IF (XX.LE.COORX(I+1)) GO TO 10
    1 CONTINUE
C     NOW EVALUATE THE CUBIC
   10 DXM = XX - COORX(I)
      DXP = COORX(I+1) - XX
      DEL = COORX(I+1) - COORX(I)
      F = FDP(I)*DXP*(DXP*DXP/DEL - DEL)/6.
     1   +FDP(I+1)*DXM*(DXM*DXM/DEL - DEL)/6.
     2   +COORY(I)*DXP/DEL + COORY(I+1)*DXM/DEL
      RETURN
      END

      SUBROUTINE SPLINE (N,COORX,COORY,FDP)
C
C     THIS SUBROUTINE COMPUTES THE SECOND DERIVATIVES NEEDED
C     IN CUBIC SPLINE INTERPOLATION.  THE INPUT DATA ARE:
C     N     = NUMBER OF DATA POINTS
C     COORX = ARRAY CONTAINING THE VALUES OF THE INDEPENDENT VARIABLE
C             (ASSUMED TO BE ASCENDING ORDER)
C     COORY = ARRAY CONTAINING THE VALUES OF THE FUNCTION AT THE
C             DATA POINTS GIVEN IN THE COORX ARRAY
      DIMENSION COORX(101),COORY(101),A(101),B(101)
      DIMENSION C(101),R(101),FDP(101)
      ALAMDA = 1
      NM2 = N - 2
      NM1 = N - 1
      C(1) = COORX(2) - COORX(1)
      DO 1 I=2,NM1
      C(I) = COORX(I+1) - COORX(I)
      A(I) = C(I-1)
      B(I) = 2.*(A(I) + C(I))
      R(I) = 6.*((COORY(I+1)-COORY(I))/C(I)-(COORY(I)
     +      -COORY(I-1))/C(I-1))
    1 CONTINUE
      B(2) = B(2) + ALAMDA * C(1)
      B(NM1) = B(NM1) + ALAMDA * C(NM1)
      DO 2 I=3,NM1
      T = A(I)/B(I-1)
      B(I) = B(I) - T * C(I-1)
      R(I) = R(I) - T * R(I-1)
    2 CONTINUE
      FDP(NM1) = R(NM1)/B(NM1)
      DO 3 I=2,NM2
      NMI = N - I
      FDP(NMI) = (R(NMI) - C(NMI) * FDP(NMI+1))/B(NMI)
    3 CONTINUE
      FDP(1) = ALAMDA * FDP(2)
      FDP(N) = ALAMDA * FDP(NM1)
C     DESIRED DERIVATIVES HAVE NOW BEEN DETERMINED
C     RETURN TO MAIN PROGRAM
      RETURN
      END

      SUBROUTINE VELDIS(SINALF,COSALF,X,Y,N,NLOWER,NUPPER,ALPHA)
C
C             COMPUTE AND PRINT OUT PRESSURE DISTRIBUTION
C
      REAL X(N),Y(N)
      INTEGER FLAG
      COMMON /FINAL/FLAG,XREF,YCORD
      COMMON /BOD/ NODTOT,COSTHE(100),SINTHE(100),NFLAG
      COMMON /COF/ A(101,111),KUTTA
      COMMON /CHARLIE/AIR
      COMMON /ABLE/NUM
      COMMON /CPD/ CP(100)
      COMMON /VISCOUS/XCORD,YCOR,CPDAT
      COMMON /NUM/ PI,PI2INV
C     COMMON /SKAL/ NZERO,YMULT
      DIMENSION    Q(150)
      DIMENSION XCORD(100),YCOR(100),CPDAT(100)
      DATA XCORD,YCOR,CPDAT /100*0.,100*0.,100*0./
C      IF (FLAG.EQ.2)THEN
C        OPEN(UNIT=47,FILE='ME5.DAT',STATUS='NEW')
C        DO I= 1,NODTOT
C          WRITE(47,999)X(I),Y(I)
C        END DO
C        WRITE(47,*)NODTOT
C        WRITE(47,*)N
C        WRITE(47,*)NUM
C        NODTOT = NODTOT-2
C        CLOSE(UNIT=47)
C      ENDIF
C     YMULT   = 20.0
      PRINT 1000, ALPHA
      WRITE (12,1000) ALPHA
      AIR = ALPHA
      PRINT 1005
      WRITE (12,1005)
C
C             RETRIEVE SOLUTION FROM A-MATRIX
C
      DO 50   I = 1,NODTOT
 50   Q(I)    = A(I,KUTTA+1)
```

```
      GAMMA    = A(KUTTA,KUTTA+1)
C
C              FIND VTAND CP AT MID-POINT OF I-TH PANEL
C
      DO 130   I = 1,NODTOT
      XMID     = .5*(X(I) + X(I+1))
      YMID     = .5*(Y(I) + Y(I+1))
      XCORD(I)= XMID
      YCOR(I) = YMID
      VTANG    = COSALF*COSTHE(I) + SINALF*SINTHE(I)
C
C              ADD CONTRIBUTION OF J-TH PANEL
C
      DO 120   J = 1,NODTOT
      FLOG     = 0.0
      FTAN     = PI
      IF (J .EQ. I) GO TO 100
      DXJ      = XMID - X(J)
      DXJP     = XMID - X(J+1)
      DYJ      = YMID - Y(J)
      DYJP     = YMID - Y(J+1)
      FLOG     = .5*ALOG((DXJP*DXJP+DYJP*DYJP)/(DXJ*DXJ+DYJ*DYJ))
      FTAN     = ATAN2(DYJP*DXJ-DXJP*DYJ,DXJP*DXJ+DYJP*DYJ)
  100 CTIMTJ   = COSTHE(I)*COSTHE(J) + SINTHE(I)*SINTHE(J)
      STIMTJ   = SINTHE(I)*COSTHE(J) - COSTHE(I)*SINTHE(J)
      AA       = PI2INV*(FTAN*CTIMTJ + FLOG*STIMTJ)
      B        = PI2INV*(FLOG*CTIMTJ - FTAN*STIMTJ)
      VTANG    = VTANG - B*Q(J) +GAMMA*AA
  120 CONTINUE
      CP(I)    = 1. - VTANG*VTANG
      CPDAT(I)=CP(I)
      PRINT 1010, XMID,CP(I)
      WRITE (12,1010) XMID,CP(I)
      WRITE (14,1010) XMID,CP(I)
  130 CONTINUE
      NUM = NODTOT
      CLOSE (UNIT=14)
  999 FORMAT(1X,F8.4,2X,F8.4)
 1000 FORMAT(/////,10X,' ANGLE OF ATTACK IN DEGREES = ',F8.3,/)
 1005 FORMAT(//,10X,' PRESSURE DISTRIBUTION',//,14X,'X',9X,'CP',/)
 1010 FORMAT(10X,F10.4,F10.4)
      RETURN
      END

      FUNCTION YREF(XNUM)
      COMMON /LEROY/NUMERAL
      COMMON /BRAVO/NUMPTS
      COMMON /CHARLIE/NO
      COMMON /FLAGGER/FIGURE
      DIMENSION FDP(101),XX(101),YY(101)
      DIMENSION XPOINT(101),YPOINT(101),XPOIN(101),YPOIN(101)
      NO = NUMPTS
C
C  READ IN THE CURRENT SHAPE OF THE AIRFOIL
C
       IF(FIGURE.EQ.2)NUMERAL=NUMERAL-2
      OPEN(UNIT=15,FILE='BODYSHAPE.DAT',STATUS='OLD')
      XX(1) = 0.0
      YY(1) = 0.0
      DO 30 I = 2,NUMERAL+1
        READ (15,*) XX(I),YY(I)
 30     CONTINUE
      XX(NUMERAL+2) = 1.
      YY(NUMERAL+2) = 0.
      CLOSE(UNIT=15)
C
C  CHECK THE INPUT OF THE AIRFOIL SHAPE DATA(OPTIONAL)
C
C     OPEN (66,FILE='MAKE.DAT',STATUS='NEW')
C     DO I = 1,NUMPTS
C       WRITE(66,999)XX(I),YY(I)
C     END DO
C 999 FORMAT(1X,F8.4,2X,F8.4)
C     CLOSE (UNIT=66)
C
C        PROVIDE BODY ORDINATES FOR A SYMMETRIC BODY.  TO DETERMINE
C        THESE POINTS A CUBIC SPLINE INTERPOLATION SUBROUTINE WAS ADDED
C        TO PROGRAM NEW_PANEL.
C
C  THE AIRFOIL SHAPE IS BEING SPLIT INTO UPPER AND LOWER SURFACES AND
C  THEN FORMATTED FOR USE WITH THE SPLINE/SPEVAL ROUTINES.
C
      NOB = INT(NUMPTS/2)+1
      DO I=1,INT(NUMPTS/2)+1
        DUMMY=XX(I)
        DUM  =YY(I)
        XPOINT(I)=DUMMY
        YPOINT(I)=DUM
      END DO
      DO I=INT(NUMPTS/2)+2,NUMPTS
        DUMM=XX(I)
        DU  =YY(I)
        XPOIN(I)=DUMM
        YPOIN(I)=DU
      END DO
        XPOIN(NUMPTS+1)=1.
        YPOIN(NUMPTS+1)=0.
        CALL SORTNUM(XPOINT,YPOINT,NOB)
        CALL SORTNUM(XPOIN,YPOIN,NOB-1)
C
C  UPPER SURFACE Y COORDINATE DETERMINATION
C
      IF (XNUM.GT.0.)THEN
        N = INT(NUMPTS/2)+1
        XPT = XNUM
        CALL SPLINE(N,XPOINT,YPOINT,FDP)
        CALL SPEVAL(N,XPOINT,YPOINT,FDP,XPT,F)
        YREF = F
      ENDIF
C
C  LOWER SURFACE Y COORDINATE DETERMINATION
C
```

```
IF (XNUM.LT.0.)THEN
  N = INT(NUMPTS/2)
  XPT = XNUM
  CALL SPLINE(N,XPOIN,YPOIN,FDP)
  CALL SPEVAL(N,XPOIN,YPOIN,FDP,XPT,F)
  YREF = F
ENDIF
RETURN
END
```

APPENDIX H. PROGRAM NEW_VOR COMPUTER CODE

```
      PROGRAM NEW_VOR
C
C *** MODIFIED FOR USE ON THE MICROVAX/2000 BY J.A. CAMPBELL (JUL 88)
C *** MODIFIED FOR GRAPHICAL OUTPUT AND/OR PRINTING OPTIONS BY C.M.
C     MACALLISTER (AUG 89)  FINAL UPDATES MADE 10 OCT 89 - (CMM)
C
C     CURRENT VERSION IS VERSION 5 INCORPORATING THE ABOVE NOTED CHANGES
C     DONE BY CRAIG MACALLISTER FOR PROFESSOR J.V. HEALEY.
C *********************************************************************
C
C     ORIGINAL IBM MAINFRAME PROGRAM WAS ADAPTED FROM JACK MORAN'S BOOK
C     'AN INTRODUCTION TO THEORETICAL AND COMPUTATIONAL AERODYNAMICS',
C     WILEY AND SONS, NEW YORK 1984.  THE LISTING IS FOUND ON PAGE 151.
C
C     SIGNIFICANT UPGRADES HAVE BEEN IMPLEMENTED IN VERSION 5 WITH
C     RESPECT TO EASE OF OPERATION AND ERROR CORRECTION.
C
      CHARACTER*1 PRINT,GRAPH,PLT1,PLT2,
     +PLT3
      INTEGER   NANS,GRAPHOPT,IFLAG
      REAL ALPHA
      DIMENSION  GAM(350)
      COMMON  DX,DY,AR,PI,IOPT,NX,NY
      COMMON /COUNTER/MANY
      COMMON /ASPECT/RATIO
      COMMON /COF/ A(350,351),NEQNS
      PI    = 3.1415926585
      NPASS = 1
C
C
C FOLLOWING LINES FOR OUTPUT FILES ADDED BY J.A. CAMPBELL (JUL88)
C   OPEN FILE FOR COEFFICIENT OUTPUT
      OPEN (UNIT=11,
     2      FILE= 'VORLAT4.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2      STATUS= 'UNKNOWN')
C
      OPEN (UNIT=12,
     2      FILE= 'VORLAT5.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2      STATUS= 'UNKNOWN')
C
      OPEN (UNIT=13,
     2      FILE= 'VORLAT6.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2       STATUS= 'UNKNOWN')
C
      OPEN (UNIT=14,
     2       FILE= 'VORLAT7.DAT',
     2       ORGANIZATION= 'SEQUENTIAL',
     2       ACCESS= 'SEQUENTIAL',
     2       RECORDTYPE= 'VARIABLE',
     2       FORM= 'FORMATTED',
     2       STATUS= 'UNKNOWN')
C
C               INPUT ASPECT RATIO (AR), NUMBERS OF VORTICES
C               IN X- AND Y- DIRECTIONS (NX,NY) AND
C               ANGLE OF ATTACK IN DEGRESS (ALPHA)
C
C  CALL LIBRARY ROUTINE TO CLEAR THE SCREEN, THE PRINT HEADER
      CALL CLRSCRN
      PRINT *
      PRINT *, ' PROGRAM VORLAT : VERSION 5 : 10 OCTOBER 89 '
      PRINT *
      PRINT *, ' VORTEX-LATTICE METHOD USED TO DETERMINE SPANWISE'
      PRINT *, ' LIFT DISTRIBUTION FOR A FLAT RECTANGULAR WING'
      PRINT *
      PRINT *
C
   10 PRINT *, ' ENTER THE ASPECT RATIO?'
      READ *,  AR
      RATIO = AR
       IF (NPASS .GT. 1)GO TO 70
   30 PRINT *, ' INPUT THE NUMBER OF VORTICES, IN THE X AND Y DIRECTIONS
     + (NX,NY)'
   32 READ *, NX,NY
      IF ((NX*NY) .GT. 350) THEN
         PRINT *, ' NX * NY MUST BE LESS THAN OR EQUAL TO 350.'
         PRINT *, ' PLEASE REENTER.'
         GO TO 32
      END IF
      MANY = NY
      IF (NPASS .GT. 1)GO TO 70
   50 PRINT *, ' WHAT IS THE ANGLE OF ATTACK IN DEGREES?'
   52 READ *, ALPHA
      IF (ALPHA .EQ. 0.) THEN
         PRINT *,' ALPHA MUST BE GREATER THAN ZERO. PLEASE REENTER.'
         GO TO 52
      ELSE IF (ALPHA .GT. 45.) THEN
         PRINT *,' ALPHA MUST BE LESS THAN 45. PLEASE REENTER.'
         GO TO 52
      END IF
      IF (NPASS .GT. 1)GO TO 72
C  60 PRINT *,' ENTER GRID SPACING OPTION (1 OR 2): (1) UNIFORM',
C    +        ' ; (2) COSINE'
C     READ *, IOPT
      IOPT = 1
      NPASS = NPASS + 1
C
**** MAKE CALCULATIONS AND ECHO CHECK THE INPUT
C
```

```
   70 DX = 1./FLOAT(NX)
      DY = AR/(2.*NY + .5)
      NEQNS = NX*NY
C
C  CALL LIBRARY ROUTINE TO CLEAR THE SCREEN
   72 CALL CLRSCRN
C
      PRINT *,' THE CURRENT VALUES ARE: '
      PRINT *
      PRINT *,'   1) ASPECT RATIO . . . . . . . . =',AR
      PRINT *,'   2) NUMBER OF VORTICES (NX,NY) =',NX,NY
      PRINT *,'   3) ANGLE OF ATTACK (DEGREES)  =',ALPHA
C     PRINT *,'   4) GRID SPACING: (1) UNIFORM, (2) COSINE =',IOPT
      PRINT *
      PRINT *,' THE CALCULATED PARAMETERS ARE: '
      PRINT *
      IF (IOPT .EQ. 1) THEN
         PRINT *,'   DELTA X =',DX
         PRINT *,'   DELTA Y =',DY
      ELSE
         PRINT *,'   SINCE COSINE SPACING WAS CHOSEN,'
         PRINT *,'   DELTA X AND DELTA Y ARE VARIABLE.'
      END IF
      PRINT *
      PRINT *,'   NUMBER OF EQUATIONS TO SOLVE =',NEQNS
      PRINT *
      PRINT *,' ARE THESE VALUES CORRECT? (YES=1, NO=2)'
   75 CALL QUERY (NANS)
      IFLAG = NANS
      IF (IFLAG .LT. 1 .OR. IFLAG .GT. 2)  THEN
          PRINT *, ' INVALID ENTRY. ENTER 1 OR 2.'
          GO TO 75
      END IF
      IF (IFLAG .EQ. 1) GO TO 90
C
      PRINT *, ' WHICH VALUE DO YOU WISH TO CORRECT? '
      PRINT *
   80 PRINT *, ' ENTER 1, 2, 3 OR 4'
      CALL QUERY (NANS)
      IFLAG = NANS
      IF (IFLAG .GT. 3)  THEN
          PRINT *, ' INVALID ENTRY. ENTER 1, 2, 3 OR 4.'
          GO TO 80
      END IF
C **** SEND CONTROL BACK TO OBTAIN CORRECT DATA ****
      GO TO (10,30,50) IFLAG
C **** CHANGE GRID TYPE ****
C     IF (IOPT .EQ. 1) THEN
C        IOPT = 2
C     ELSE
C        IOPT = 1
C     END IF
      GO TO 72
C
  90  COSALF = COS(ALPHA*PI/180.)
```

```
      SINALF = SIN(ALPHA*PI/180.)
C
C     INFORM OPERATOR THAT PROCESSING HAS STARTED
      WRITE (6,1003)
C
C    SET COEFFICIENTS OF EQUATIONS FOR VORTEX STRENGTHS
C
      DO 100 I = 1,NY
        DO 100 J = 1,NX
          IJ = (I - 1)*NX + J
          A(IJ,NEQNS + 1) = SINALF
            DO 100 K = 1,NY
            DO 100 L = 1,NX
              KL = (K-1)*NX + L
              CALL DNWASH (I,J,K,L,A(KL,IJ),1)
  100 CONTINUE
C
C     SOLVE FOR VORTEX STRENGTHS
C
      CALL GAUSS (1)
      DO 200 I = 1,NY
        DO 200 J = 1,NX
          IJ = (I-1)*NX + J
  200 GAM(IJ) = A(IJ,NEQNS+1)
C
C     PRINT OUT HEADINGS FOR DATA
C
      IF (IOPT .EQ. 1) WRITE (11,1000) NX,NY,AR,ALPHA
      IF (IOPT .EQ. 2) WRITE (11,1001) NX,NY,AR,ALPHA
      WRITE (6,1005)
      WRITE (11,1005)
C
C     INITIALIZE TOTAL FORCE AND MOMENT COEFFICIENTS
C
      CMT = 0.0
      CDT = 0.0
      CLT = 0.0
C
C     COMPUTE FORCE AND MOMENT COEFFICIENTS
C
      Y = 0.00
      CL = 0.00
      CD = 0.00
      XCP= .25
      WRITE(12,1010) Y,CL,CD,XCP
      WRITE(13,1010) Y,CL,CD,XCP
      WRITE(14,1010) Y,CL,CD,XCP
      DO 320 I = 1,NY
        CX = 0.0
        CZ = 0.0
        CM = 0.0
C
        DO 310 J = 1,NX
          IJ = (I-1)*NX + J
          W = 0.0
            DO 300 K = 1,NY
```

```
              DO 300 L = 1,NX
                KL = (K-1)*NX + L
                CALL DNWASH(K,L,I,J,DELW,2)
                W = W + DELW*GAM(KL)
  300         CONTINUE
            CX = CX + GAM(IJ)*(W - SINALF)*2.
            CZ = CZ + GAM(IJ)*COSALF*2.
            IF (IOPT .EQ. 1) THEN
               CM = CM - GAM(IJ)*DX*(J - .75)*COSALF*2.
            ELSE
               CM = CM - GAM(IJ)*(FCOS(J,NX)+0.25*(FCOS(J+1,NX)
     +           - FCOS(J,NX)))*COSALF*2.
            END IF
  310     CONTINUE
          CL = CZ*COSALF - CX*SINALF
          CD = CZ*SINALF + CX*COSALF
          IF (IOPT .EQ. 1) THEN
             CLT =  CLT + CL*DY*2./AR
             CDT = CDT + CD*DY*2./AR
             CMT = CMT + CM*2.*DY/AR
          ELSE
CCC          DELY = (0.5*AR - 0.25*DY)*(FSIN(I+1,NY) - FSIN(I,NY))
             DELY = (0.5*AR - 0.25*DY)*(FCOS(I+1,NY) - FCOS(I,NY))
             CLT = CLT + CL*DELY*2./AR
             CDT = CDT + CD*DELY*2./AR
             CMT = CMT + CM*DELY*2./AR
          END IF
          XCP = - CM/CL
          IF (IOPT .EQ. 1) THEN
             Y = (I-.5)*DY
          ELSE
CCC          Y = (0.5*AR - 0.25*DY)*0.5*(FSIN(I,NY) + FSIN(I+1,NY))
             Y = (0.5*AR - 0.25*DY)*(FCOS(I,NY) +
     +            0.5*(FCOS(I+1,NY) - FCOS(I,NY)))
          END IF
          WRITE(6,1010) Y,CL,CD,XCP
          WRITE(11,1010) Y,CL,CD,XCP
          WRITE(12,1010) Y,CL,CD,XCP
          WRITE(13,1010) Y,CL,CD,XCP
          WRITE(14,1010) Y,CL,CD,XCP
  320 CONTINUE
      XCP = -CMT/CLT
      CDOCL2 = CDT/CLT**2
      WRITE(6,1020) CLT,CDT,CDOCL2,CMT,XCP
      WRITE(11,1020) CLT,CDT,CDOCL2,CMT,XCP
      CLOSE(UNIT=11)
      CLOSE(UNIT=12)
      CLOSE(UNIT=13)
      CLOSE(UNIT=14)
C
      PRINT *
      PRINT *, ' THE COEFFICIENT OUTPUT DATA FOR LIFT, DRAG AND'
      PRINT *, ' PRESSURE HAS BEEN WRITTEN TO FILE VORLAT4.DAT.'
      PRINT *
      PRINT *, 'WOULD YOU LIKE TO PRINT THE RESULTS (Y/N)?'
      PRINT *
      READ 1002, PRINT
      IF (PRINT.EQ.'Y'.OR.PRINT.EQ.'y')THEN
         CALL LIB$SPAWN('PRINT VORLAT4.DAT')
      ENDIF
      PRINT *
      PRINT *, 'WOULD YOU LIKE TO GRAPH THE RESULTS (Y/N)?'
      PRINT *
      READ 1002, GRAPH
      IF (GRAPH.EQ.'Y'.OR.GRAPH.EQ.'y')THEN
 46   PRINT *
      PRINT *, 'WHICH OF THE FOLLOWING RELATIONSHIPS'
      PRINT *, '       DO YOU WANT TO GRAPH?'
      PRINT *
      PRINT *, '             1)  CL VS.  Y'
      PRINT *, '             2)  CD VS.  Y'
      PRINT *, '             3)  CL VS.  CD'
      PRINT *, '             4)  NONE'
      PRINT *
      PRINT *, 'INPUT OPTION NO.(1,2,3 OR 4)'
 65   READ 1006, GRAPHOPT
      IF (GRAPHOPT .LT. 1 .OR. GRAPHOPT .GT. 4) THEN
         PRINT *, 'INVALID ENTRY, ENTER INTEGER BETWEEN'
         PRINT *, 'ONE(1) AND FOUR(4).'
         PRINT *, ' '
         GO TO 65
      ENDIF
      IF (GRAPHOPT .EQ. 1) THEN
       CALL PLOT1(ALPHA)
C     GET A HARDCOPY OF THIS GRAPHIC
       CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
     +SIZE=A P1.UIS')
      PRINT *, ' '
      PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
      PRINT *, ' '
      READ 1002, PLT1
      IF (PLT1.EQ.'Y'.OR.PLT1.EQ.'y')THEN
        CALL LIB$SPAWN('PRINT P1.REN')
      ENDIF
      GO TO 46
      ENDIF
      IF (GRAPHOPT .EQ. 2) THEN
       CALL PLOT2(ALPHA)
       CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
     +SIZE=A P2.UIS')
      PRINT *, ' '
      PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
      PRINT *, ' '
      READ 1002, PLT2
      IF (PLT2.EQ.'Y'.OR.PLT2.EQ.'y')THEN
        CALL LIB$SPAWN('PRINT P2.REN')
      ENDIF
      GO TO 46
      ENDIF
      IF (GRAPHOPT .EQ. 3) THEN
       CALL PLOT3(ALPHA)
       CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
     +SIZE=A P3.UIS')
      PRINT *, ' '
      CALL LIB$SPAWN('CONTINUE')
      PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
      PRINT *, ' '
      READ 1002, PLT3
      IF (PLT3.EQ.'Y'.OR.PLT3.EQ.'y')THEN
        CALL LIB$SPAWN('PRINT P3.REN')
      ENDIF
      GO TO 46
      ENDIF
      IF (GRAPHOPT .EQ. 4) THEN
        GO TO 64
      ENDIF
      ENDIF
C          OPTION TO MAKE ANOTHER RUN
   64 PRINT *
      PRINT *, ' DO YOU WISH TO:    '
      PRINT *, '       1) MAKE ANOTHER RUN OR'
      PRINT *, '       2) END THIS SESSION'
      PRINT *, ' ENTER 1 OR 2.'
      PRINT *
      CALL QUERY (NANS)
      CALL CLRSCRN
      IF (NANS .EQ. 1)  GO TO 72
      STOP
 1000 FORMAT(//,10X,' ** UNIFORM GRID SPACING **',///,10X,
     +       '     NX= ',I2,'  NY= ',I2,'   ASPECT RATIO = ',F5.2,
     &/,16X,'   ANGLE OF ATTACK = ', F5.2)
 1001 FORMAT(//,10X,' ** COSINE GRID SPACING **',///,10X,
     +       '     NX= ',I2,'  NY= ',I2,'   ASPECT RATIO = ',F5.2,
     +/,16X,'   ANGLE OF ATTACK = ',F5.2)
 1002 FORMAT(A1)
 1006 FORMAT(I1)
 1003 FORMAT(//,' PROCESSING BEGINS....',///)
 1005 FORMAT (////,10X,'   Y       CL(Y)     CD(Y)     XCP(Y)',/)
 1010 FORMAT(10X,F6.3,3F10.5)
 1020 FORMAT(/////,10X,' CL =',F12.5,/,10X,' CD =',F14.7,/,10X,
     +' CD/CL2 =',F7.4,/,10X,' CMLE =',F11.6,/,10X,' XCP =',F11.5)
      END

      SUBROUTINE CLRSCRN
C
C  LIBRARY ROUTINE TO CLEAR THE SCREEN.
C
      ISTAT = LIB$ERASE_PAGE (1,1)
      RETURN
      END
C
      SUBROUTINE QUERY(NANS)
C
C  ROUTINE TO TRAP ERRORS CAUSED BY IMPROPER RESPONSES TO QUESTIONS.
C  THE COMPUTER GENERATES AND ERROR WHEN A CHARACTER IS SUPPLIED TO
C  A QUESTION EXPECTING AN INTEGER OR REAL VALUE.
C
      NQTEST=0
```

```
    1 CONTINUE
      IF (NQTEST .GT. 0) THEN
         PRINT *, '  CHARACTER VALUES ARE NOT VALID.'
         PRINT *, '  PLEASE ENTER AN INTEGER VALUE.'
      END IF
      NQTEST = NQTEST + 1
      READ (5,*,ERR=1)NANS
      RETURN
      END

      SUBROUTINE DNWASH(I,J,K,L,W,IND)
C
C     COMPUTE DOWNWASH ON PANEL CENTERED AT (L-.5)DX,(K-.5)DY
C     DUE TO VORTICES AT PANELS CENTERED AT (J-.5)DX,+-(I-.5)DY
C
      COMMON DX,DY,AR,PI,IOPT,NX,NY
C
      IF (IOPT .EQ. 2) GO TO 50
      XA = DX*(J - .75)
      YA = DY*(I - 1)
      YB = DY*I
      IF (IND .EQ. 1) XP = DX*(L - .25)
      IF (IND .EQ. 2) XP = DX*(L - .75)
      YP = DY*(K-.5)
      GO TO 60
C     THE FOLLOWING LINES HANDLE THE COSINE SPACING SCHEME
C     FAC IS THE HALF SPAN MINUS A 1/4 LATTICE WIDTH INSET.
 50   FAC = 0.5*AR - 0.25*DY
      XA = FCOS(J,NX) + 0.25*(FCOS(J+1,NX) - FCOS(J,NX))
CCC   YA = FAC * FSIN(I-1,NY)
CCC   YB = FAC * FSIN(I,NY)
      YA = FAC * FCOS(I,NY)
      YB = FAC * FCOS(I+1,NY)
      IF (IND .EQ. 1) XP = FCOS(L,NX) + .75*(FCOS(L+1,NX) - FCOS(L,NX))
      IF (IND .EQ. 2) XP = FCOS(L,NX) + .25*(FCOS(L+1,NX) - FCOS(L,NX))
CCC   YP = FAC*0.5*(FSIN(K,NY) + FSIN(K-1,NY))
      YP = FAC*(FCOS(K,NY) + 0.5*(FCOS(K+1,NY) - FCOS(K,NY)))
C
 60   W = WHV(XP,YP,XA,YA) - WHV(XP,YP,XA, YB)
     +    - WHV(XP,YP,XA,-YA) + WHV(XP,YP,XA,-YB)
      W = W*.25/3.1415926585
      RETURN
      END

      FUNCTION WHV(X1,Y1,X2,Y2)
        IF (X1 .EQ. X2)  GO TO 100
        WHV = (1. + SQRT(( X1-X2)**2 + (Y1-Y2)**2)/(X1 - X2))
     +         /(Y1 - Y2)
        RETURN
  100     WHV = 1./(Y1 - Y2)
        RETURN
      END

C     THIS RETURNS THE NONDIMENSIONAL X COORD OF EACH SECTION BOUNDARY
C
      FUNCTION FCOS(I,N)
```

```
          PI = 3.1415926585
          FRACT = FLOAT(I-1)/FLOAT(N)
          FCOS = 0.5 * (1. - COS(PI*FRACT))
          RETURN
        END

C       THIS RETURNS THE NONDIMENSIONAL Y COORD OF EACH SECTION BOUNDARY
C       THIS WAS INTENDED TO IMPLEMENT THE SIN-LAW LATTICE SPACING SCHEME
C       REFERRED TO BY GARY HOUGH, JOU. OF ACFT., MAY 1973, VOL.10, NO.5
C
        FUNCTION FSIN(I,N)
          PI = 3.1415926585
          FRACT = FLOAT(I)/FLOAT(N)
          FSIN =  (SIN(.5*PI*FRACT))
          RETURN
        END

        SUBROUTINE GAUSS (NRHS)
C
C          SOLUTION OF LINEAR ALGEBRAIC SYSTEM BY
C          GAUSS ELIMINATION WITH PARTIAL PIVOTING
C
C               °A        = COEFFICIENT MATRIX
C               NEQNS     = NUMBER OF EQUATIONS
C               NRHS      = NUMBER OF RIGHT HAND SIDES
C
C               RIGHT-HAND SIDES AND SOLUTIONS STORED IN
C               COLUMNS NEQNS+1 THRU NEQNS+NRHS OF °A
C
        COMMON DX,DY,AR,PI
        COMMON /COF/ A(350,351),NEQNS
        NP      = NEQNS + 1
        NTOT    = NEQNS + NRHS
C
C               GAUSS REDUCTION
C
        DO 150  I = 2,NEQNS
C
C               --  SEARCH FOR LARGEST ENTRY IN (I-1)TH COLUMN
C                   ON OR BELOW MAIN DIAGONAL
C
          IM      = I - 1
          IMAX    = IM
          AMAX    = ABS(A(IM,IM))
          DO 110  J = I,NEQNS
            IF (AMAX .GE. ABS(A(J,IM))) GO TO 110
            IMAX    = J
            AMAX    = ABS(A(J,IM))
  110     CONTINUE
C
C               --   SWITCH (I-1)TH AND IMAXTH EQUATIONS
C
          IF (IMAX .NE. IM)   GO TO 140
          DO 130  J = IM,NTOT
            TEMP    = A(IM,J)
            A(IM,J) = A(IMAX,J)
```

```
         A(IMAX,J) = TEMP
 130    CONTINUE
C
C              ELIMINATE (I-1)TH UNKNOWN FROM
C              ITH THRU (NEQNS)TH EQUATIONS
C
 140  DO 150  J = I,NEQNS
              R = A(J,IM)/A(IM,IM)
        DO 150  K = I,NTOT
 150       A(J,K) = A(J,K) - R*A(IM,K)
C
C              BACK SUBSTITUTION
C
      DO 220  K = NP,NTOT
        A(NEQNS,K) = A(NEQNS,K)/A(NEQNS,NEQNS)
        DO 210  L = 2,NEQNS
          I       = NEQNS + 1 - L
          IP      = I + 1
          DO 200  J = IP,NEQNS
 200        A(I,K)  = A(I,K) - A(I,J)*A(J,K)
 210        A(I,K)  = A(I,K)/A(I,I)
 220  CONTINUE
      RETURN
      END

      SUBROUTINE  MAXMIN(ARRAY,NY,VALMAX,VALMIN)
C
C  ARRAY = THE ARRAY WHICH IS BEING SORTED INTO ASCENDING ORDER
C  NUMBER= THE NUMBER OF ELEMENTS IN THE ARRAY TO BE SORTED
C  VALMAX= LARGEST VALUE IN THE ARRAY
C  VALMIN= SMALLEST VALUE IN THE ARRAY
      REAL VALMAX,VALMIN
      INTEGER NUMBER
      LOGICAL SORTED
      DIMENSION ARRAY(100)
      SORTED = .FALSE.
      NUMBER = NY
  30  IF (.NOT.SORTED) THEN
         SORTED = .TRUE.
         DO 40 I = 1,NUMBER - 1
           IF(ARRAY(I).GT.ARRAY(I+1))THEN
             VALUE = ARRAY(I)
             ARRAY(I) = ARRAY(I+1)
             ARRAY(I+1) = VALUE
             SORTED = .FALSE.
           ENDIF
  40     CONTINUE
         GO TO 30
      ENDIF
      VALMAX = ARRAY(NUMBER)
      VALMIN = ARRAY(1)
      RETURN
      END
      SUBROUTINE PLOT1(ALPHA)
C
C    DEFINE IPACK ARRAY FOR LEGEND
      INTEGER*4 IPACK(35)
      INTEGER NUMBER
      REAL YY(100),CD(100),CL(100),XCP(100)
      REAL BA,MAX,MIN,AR
      CHARACTER*40 L1
      COMMON /COUNTER/MANY
      COMMON /ASPECT/RATIO
      DIMENSION YY1(100),CL1(100)
C    READ ELEMENTS OF UNIT 12 INTO ARRAYS TO PLOT
       NUMBER = MANY
       BA=ALPHA
       OPEN(UNIT=12,FILE='VORLAT5.DAT',STATUS='OLD')
       DO 25 I = 1,MANY+1
         READ (12,*)YY(I),CL(I),CD(I),XCP(I)
         DUM = YY(I)
         DUMM= CL(I)
         YY1(I)=DUM
         CL1(I)=DUMM
   25  CONTINUE
       CLOSE(UNIT=12)
       CALL MAXMIN(CL1,MANY+1,MAX,MIN)
       CALL MAXMIN(YY1,MANY+1,VALMAX,VALMIN)
C    DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
       L1 = 'CL VALUES$'
C    INITIALIZE THE GRAPHICS SYSTEM
       CALL INIT
C    LABEL X AND Y AXES USING SELF COUNTING STRINGS
       CALL XNAME('Y$',100)
       CALL YNAME('CL$',100)
C    DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
       CALL AREA2D(6.0,8.0)
C    DEFINE HEADING LABEL
       CALL HEADIN('CL VS.  Y$',-100,2.,1)
C    PLOT ADDITIONAL TICK MARKS
       CALL XTICKS(1)
       CALL YTICKS(1)
C    PACK LEGEND LABELS INTO ARRAY IPACK
       CALL LINES(L1,IPACK,1)
C    SET UP AXIS
       CALL GRAF(0.,((VALMAX-VALMIN)/5.),(VALMAX+.1),0.,
     +      ((MAX-MIN)/2.),(MAX+.1))
C    FRAME THE SUBPLOT AREA
       CALL FRAME
C    PLOT PRESSURE DISTRIBUTION DATA WITH A THICK LINE AND MARKER 15
       CALL MARKER(15)
       CALL THKCRV(.04)
       CALL CURVE(YY,CL,NUMBER+1,1)
C    PLOT MESSAGES
         CALL MESSAG('FLAT RECTANGULAR WING$',100,
     + .75,1.5)
         CALL MESSAG('ASPECT RATIO(AR) = $',100,.75,1.)
         CALL REALNO(RATIO,2,3.5,1.)
         CALL MESSAG('ANGLE OF ATTACK = $',100,.75,.5)
```

```
          CALL REALNO(BA,2,3.5,.5)
C     CHANGE LEGEND NAME TO "2-D PLOT"
        CALL MYLEGN('2-D PLOT$',100)
C     PLOT LEGEND
        CALL LEGEND(IPACK,1,2.0,7.0)
C     END PLOT
        CALL ENDPL(0)
C     CREATE GRAPHICS METAFILE P1.UIS
        CALL METAFL(1)
C     TERMINATE PLOT AT END OF PLOTTING SESSION
        CALL DONEPL
        RETURN
        END

       SUBROUTINE PLOT2(ALPHA)
C
C     DEFINE IPACK ARRAY FOR LEGEND
       INTEGER*4 IPACK(35)
       INTEGER NUM,MANY
       REAL YY(100),CD(100),CL(100),XCP(100)
       REAL BAD,MAX,MIN,ALPHA,AR
       CHARACTER*40 L1
       COMMON /COUNTER/MANY
       COMMON /ASPECT/RATIO
       DIMENSION YY1(100),CD1(100)
C     READ ELEMENTS OF UNIT 13 INTO ARRAYS TO PLOT
        NUM = MANY
        OPEN(UNIT=13,FILE='VORLAT6.DAT',STATUS='UNKNOWN')
        DO 25 I = 1,MANY+1
          READ (13,*)YY(I),CL(I),CD(I),XCP(I)
          DUM = YY(I)
          DUMM= CD(I)
          YY1(I)=DUM
          CD1(I)=DUMM
  25    CONTINUE
        CLOSE(UNIT=13)
        CALL MAXMIN(CD1,MANY+1,MAX,MIN)
        CALL MAXMIN(YY1,MANY+1,VALMAX,VALMIN)
C     DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
        L1 = 'CD VALUES$'
C     INITIALIZE THE GRAPHICS SYSTEM
        CALL INIT
C     LABEL X AND Y AXES USING SELF COUNTING STRINGS
        CALL XNAME('Y$',100)
        CALL YNAME('CD$',100)
C     DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
        CALL AREA2D(6.0,8.0)
C     DEFINE HEADING LABEL
        CALL HEADIN('CD VS.  Y$',-100,2.,1)
C     PLOT ADDITIONAL TICK MARKS
        CALL XTICKS(1)
        CALL YTICKS(1)
C     PACK LEGEND LABELS INTO ARRAY IPACK
        CALL LINES(L1,IPACK,1)
C     SET UP AXIS
        CALL GRAF(0.,((VALMAX-VALMIN)/5.),(VALMAX+.1),0.,
     +     ((MAX-MIN)/3.),(MAX+.001))
C    FRAME THE SUBPLOT AREA
       CALL FRAME
C    PLOT PRESSURE DISTRIBUTION DATA WITH A THICK LINE AND MARKER 15
       CALL MARKER(15)
       CALL THKCRV(.04)
       CALL CURVE(YY,CD,NUM+1,1)
C    PLOT MESSAGES
         CALL MESSAG('FLAT RECTANGULAR WING$',100,
     + .75,1.5)
         CALL MESSAG('ASPECT RATIO(AR) = $',100,.75,1.)
         CALL REALNO(RATIO,2,3.5,1.)
         CALL MESSAG('ANGLE OF ATTACK = $',100,.75,.5)
         CALL REALNO(ALPHA,2,3.5,.5)
C    CHANGE LEGEND NAME TO "2-D PLOT"
       CALL MYLEGN('2-D PLOT$',100)
C    PLOT LEGEND
       CALL LEGEND(IPACK,1,2.0,7.0)
C    END PLOT
       CALL ENDPL(0)
C    CREATE GRAPHICS METAFILE P2.UIS
       CALL METAFL(2)
C    TERMINATE PLOT AT END OF PLOTTING SESSION
       CALL DONEPL
       RETURN
       END

      SUBROUTINE PLOT3(ALPHA)
C
C    DEFINE IPACK ARRAY FOR LEGEND
      INTEGER*4 IPACK(35)
      INTEGER NUMB
      REAL YY(100),CD(100),CL(100),XCP(100)
      REAL MAXY,MINY,MAX,MIN,ALPHA,AR,BED
      CHARACTER*40 L1
      COMMON /COUNTER/MANY
      COMMON /ASPECT/RATIO
C    READ ELEMENTS OF UNIT 14 INTO ARRAYS TO PLOT
       NUMB = MANY
       OPEN(UNIT=14,FILE='VORLAT7.DAT',STATUS='OLD')
       DO 25 I = 1,MANY+1
         READ (14,*)YY(I),CL(I),CD(I),XCP(I)
  25   CONTINUE
       CLOSE(UNIT=14)
       CALL MAXMIN(CL,MANY+1,MAX,MIN)
       CALL MAXMIN(CD,MANY+1,MAXY,MINY)
C    DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
       L1 = 'CL/CD VALUES$'
C    INITIALIZE THE GRAPHICS SYSTEM
       CALL INIT
C    LABEL X AND Y AXES USING SELF COUNTING STRINGS
       CALL XNAME('CD$',100)
       CALL YNAME('CL$',100)
C    DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
       CALL AREA2D(6.0,8.0)
C    DEFINE HEADING LABEL
```

```
        CALL HEADIN('CL VS. CD$',-100,2.,1)
C     PLOT ADDITIONAL TICK MARKS
        CALL XTICKS(1)
        CALL YTICKS(1)
C     PACK LEGEND LABELS INTO ARRAY IPACK
        CALL LINES(L1,IPACK,1)
C     SET UP AXIS
        CALL GRAF(0.,((MAXY-MINY)/5.),(MAXY+.001),
     +0.,((MAX-MIN)/5),(MAX+.01))
C     FRAME THE SUBPLOT AREA
        CALL FRAME
C     PLOT PRESSURE DISTRIBUTION DATA WITH A THICK LINE AND MARKER 15
        CALL MARKER(15)
        CALL THKCRV(.04)
        CALL CURVE(CD,CL,NUMB,1)
C     PLOT MESSAGES
          CALL MESSAG('FLAT RECTANGULAR WING$',100,
     + 1.75,1.5)
          CALL MESSAG('ASPECT RATIO(AR) = $',100,1.75,1.)
          CALL REALNO(RATIO,2,4.5,1.)
          CALL MESSAG('ANGLE OF ATTACK = $',100,1.75,.5)
          CALL REALNO(ALPHA,2,4.5,.5)
C     CHANGE LEGEND NAME TO "2-D PLOT"
        CALL MYLEGN('2-D PLOT$',100)
C     PLOT LEGEND
        CALL LEGEND(IPACK,1,2.0,7.0)
C     END PLOT
        CALL ENDPL(0)
C     CREATE GRAPHICS METAFILE P3.UIS
        CALL METAFL(3)
C     TERMINATE PLOT AT END OF PLOTTING SESSION
        CALL DONEPL
        RETURN
        END

       END
```

APPENDIX I. PROGRAM SUB COMPUTER CODE

```
      PROGRAM SUB
C
C *** MODIFIED FOR USE ON THE MICROVAX/2000 BY R. MARGASON.
C *** MODIFIED FOR GRAPHICAL OUTPUT AND/OR PRINTING OPTIONS BY C. M.
C     MACALLISTER (AUB 89) FINAL UPDATES MADE OCT 89 - (CMM).
C
C     THE SUB PROGRAM HAS BEEN ADAPTED FROM A NATIONAL AERONAUTICS AND
C     SPACE ADMINISTRATION(NASA) FORTRAN PROGRAM AND HAS BEEN USED CON-
C     SIDERABLY AT THE LANGLEY RESEARCH CENTER. THE PURPOSE OF THE SUB
C     PROGRAM IS TO ESTIMATE THE SUBSONIC AERODYNAMIC CHARACTERISTICS
C     OF COMPLEX PLANFORMS.  THE PROGRAM REPRESENTS A LIFTING PLANFORM
C     WITH A VORTEX LATTICE.  A RELATIVELY COMPLEX PLANFORM MAY BE
C     ANALYZED BY CREATING THE PLANFORM WITH UP TO 24 LINE SEGMENTS ON
C     A SEMISPAN.  ADDITIONALLY, THESE LINE SEGMENTS MAY HAVE AN OUT-
C     BOARD VARIABLE-SWEEP PANEL OR THEY MAY HAVE SEVERAL DIHEDRAL ANGLES
C     ACROSS THE SPAN.  FURTHERMORE, TWO PLANFORMS MAY BE USED TOGETHER
C     TO REPRESENT A COMBINATION OF WINGS AND TAILS OR WING, BODIES, AND
C     TAILS.  THE USE OF THIS PROGRAM IS CONFINED TO THE SUBSONIC FLOW
C     REGIME.  ADDITIONALLY, THE PLANFORM IS IN STEADY, IRROTATIONAL,
C     INVISCID, INCOMPRESSIBLE, ATTACHED FLOW CONDITIONS.
C
      CHARACTER*20  CASEFN, OUTFIL
      INTEGER GRAPHOPT,OUTER,LSTA,NSTA,METH
      CHARACTER*1 PRINT,GRAPH,COPY,PLOT1,PLOT2,PLOT3
      CHARACTER*1 PLOT4,PLOT5,PLOT6
      REAL MACH
      COMMON/SHIP/VIC,SCW
      COMMON/ALL/ BOT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(300),PN(300),
     1            PV(300),ALP(300),S(300),PSI(300),PHI(300),ZH(50)
      COMMON/TOTHRE/ CIR(300,2),SECTRST(50)
      COMMON/ONETHRE/TWIST(2),CREF,SREF,CAVE,CLDES,STRUE,AR,ARTRUE,
     1   RTCDHT(2),CONFIG,NSSWSV(2),MSV(2),KBOT,PLAN,IPLAN,MACH
     2    ,SSWWA(50)
      COMMON/MAINONE/ICODEOF,TOTAL,AAN(2),XS(2),YS(2),KFCTS(2)
     1       ,XREG(25,2),YREG(25,2),AREG(25,2),DIH(25,2),MCD(25,2)
     2       ,XX  (25,2),YY  (25,2),AS  (25,2),TTWD(25,2),MMCD(25,2)
     3       ,AN(2),ZZ (25,2)
    7 FORMAT(   //10X,I6,'HORSESHOE VORTICES LAYOUT, THIS IS MORE THAN
     1THE 300 MAXIMUM. THIS CONFIGURATION IS ABORTED.')
    8 FORMAT (   // 10X, I6,' ROWS OF HORSESHOE VORTICES LAIDOUT. THIS I
     1S MORE THAN THE 50 MAXIMUM. THIS CONFIGURATION IS ABORTED.' )
    9 FORMAT (    // 10X, 'PLANFORM',I6,' HAS',I6,
     1 ' BREAKPOINTS. THE MAXIMUM DIMENSIONED IS 25. THE CONFIGURATION I
     2S ABORTED.')
  100 FORMAT (A20)
  101 FORMAT (///'   START OF A NEW CASE, CASE FILE NAME IS ', A20//)
  102 FORMAT (  '    THE OUTPUT FILE NAME IS "OUTFILE.DAT" ', //)
C
C         VORTEX LATTICE AERODYNAMIC COMPUTATION
C              NASA-LRC PROGRAM NO. A2794
C
C
C
      METH   = INT(VIC)
      NMAX   = 300
      ICODEOF=   0
      TOTAL  =   0
C          INPUT FILE NAME OF THE CASE TO BE RUN
C
  1   WRITE(*,*) ' '
      WRITE(*,*) ' PROGRAM SUB - SUBSONIC VORTEX LATTICE ANALYSIS'
      PRINT *, ' '
      WRITE(*,*) '           ENTER INPUT DATA FILE NAME  '
      WRITE(*,*) 'USE  LAST.END  AS DATA FILE NAME TO STOP THE PROGRAM'
      PRINT *, ' '
      READ(*,100)  CASEFN
      IF (CASEFN.EQ.'LAST.END') GO TO 999
      IF (CASEFN.EQ.'last.end') GO TO 999
      OPEN(28,FILE=CASEFN,STATUS='OLD')
C
C       CREATE FILES WHICH WILL BE USED TO PLOT THE RESULTS
C
C    OPEN FILE FOR SPANWISE PRESSURE DISTRIBUTION OUTPUT
      OPEN (UNIT=11,
     2      FILE= 'AERO1.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2      STATUS= 'UNKNOWN')
C
C    OPEN FILE FOR DRAG POLAR OUTPUT
      OPEN (UNIT=12,
     2      FILE= 'AERO2.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2      STATUS= 'UNKNOWN')
C
C    OPEN FILE FOR CP OUTPUT
      OPEN (UNIT=13,
     2      FILE= 'AERO3.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2      STATUS= 'UNKNOWN')
C
      OPEN (29, FILE ='OUTFILE.DAT', STATUS = 'NEW' )
C
      WRITE(29,101)  CASEFN
      WRITE(29,102)
C
   11 CALL GEOM
      IF(ICODEOF.GT.0) GO TO 99
      IF(M.GT.NMAX) GO TO 2
      NSW     = NSSWSV(1) + NSSWSV(2)
      IF  ( NSW.GT.50 )                 GO TO 4
      ITSV  = 0
      DO 10 IT=1,IPLAN
      IF ( AN(IT).LE.25. )                GO TO 10
      WRITE (29,9)  IT,AN(IT)
      ITSV = 1
   10 CONTINUE
      IF (ITSV.GT.0)                      GO TO 5
      GO TO 3
    4 WRITE (29,8) NSW
      GO TO 5
    2 WRITE(29,7) M
      GO TO 5
    3 CALL MATX
      CALL AERO
    5 TOTAL=TOTAL-1.
      IF  ( TOTAL.GT.0. ) GO TO 11
  99  CLOSE(UNIT=28)
      CLOSE(UNIT=29)
      PRINT *
      PRINT *, '  PROGRAM RESULTS HAVE BEEN WRITTEN TO THE FILE'
      PRINT *, '                 OUTFILE.DAT.'
      PRINT *, 'WOULD YOU LIKE A PRINTED COPY OF THIS OUTPUT FILE?'
      PRINT *, '              YES OR NO (Y/N)'
      PRINT *
      READ 1002, PRINT
 1002 FORMAT(A1)
      IF (PRINT.EQ.'Y')THEN
        CALL LIB$SPAWN('PRINT OUTFILE.DAT')
      ENDIF
      PRINT *
      PRINT *, 'WOULD YOU LIKE THE OUTPUT FILE COPIED TO ANOTHER'
      PRINT *, '      FILE FOR FUTURE REFERENCE (Y/N) ? '
      PRINT *
      READ 1002,COPY
      IF (COPY .EQ.'Y') THEN
        PRINT *, 'WHAT NAME WOULD YOU LIKE FOR THE OUTPUT FILE?'
        PRINT *, ' '
        PRINT *, '                1)  VIGILANTE.DAT'
        PRINT *, '                2)  CORSAIR.DAT'
        PRINT *, '                3)  HAWKEYE.DAT'
        PRINT *, '                4)  SKYHAWK.DAT'
        PRINT *, ' '
        PRINT *, 'ENTER 1,2,3 OR 4'
   69   READ 1006, OUTER
      IF (OUTER .LT. 1 .OR. OUTER .GT. 4) THEN
         PRINT *, 'INVALID ENTRY, ENTER INTEGER BETWEEN'
         PRINT *, 'ONE(1) AND FOUR(4).'
         PRINT *, ' '
         GO TO 69
      ENDIF
        IF (OUTER.EQ.1) CALL LIB$SPAWN('COPY OUTFILE.DAT VIGILANTE.DAT')
        IF (OUTER.EQ.2) CALL LIB$SPAWN('COPY OUTFILE.DAT CORSAIR.DAT')
        IF (OUTER.EQ.3) CALL LIB$SPAWN('COPY OUTFILE.DAT HAWKEYE.DAT')
        IF (OUTER.EQ.4) CALL LIB$SPAWN('COPY OUTFILE.DAT SKYHAWK.DAT')
      ENDIF
      PRINT *,'WOULD YOU LIKE TO GRAPH THE RESULTS (Y/N)?'
      PRINT *
      READ 1002,GRAPH
      IF (GRAPH .EQ.'Y')THEN
      PRINT *, ' '
      PRINT *, ' '
   41 PRINT *, 'WHICH OF THE FOLLOWING RELATIONSHIPS'
      PRINT *, '      DO YOU WANT PLOTTED?'
      PRINT *
      PRINT *, '    1) INDUCED DRAG COEFF VS. 2Y/B'
      PRINT *, '    2) LE EDGE THRUST COEFF VS. 2Y/B'
      PRINT *, '    3) SUCTION COEFF VS. 2Y/B'
      PRINT *, '    4) SPAN LOAD COEFF VS. 2Y/B'
      PRINT *, '    5) CL RATIO VS. 2Y/B'
      PRINT *, '    6) DELTA CP VS. X C/4'
      PRINT *, '    7) NONE'
      PRINT *
      PRINT *, 'INPUT OPTION NO. (1,2,3,4,5,6 OR 7)'
   42 READ 1006, GRAPHOPT
      IF (GRAPHOPT .LT. 1 .OR. GRAPHOPT .GT. 7) THEN
         PRINT *, 'INVALID ENTRY, ENTER INTEGER BETWEEN'
         PRINT *, 'ONE(1) AND SEVEN(7).'
         PRINT *, ' '
         GO TO 42
      ENDIF
C ******************************************************
      IF (GRAPHOPT .EQ. 1) THEN
       CALL GRAPH1
C    GET A HARDCOPY OF THIS GRAPHIC
       CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
     +SIZE=A P1.UIS')
      CALL LIB$SPAWN('CONTINUE')
      PRINT *, ' '
      PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
      PRINT *, ' '
      READ 1002, PLOT1
      IF (PLOT1.EQ.'Y'.OR.PLOT1.EQ.'y')THEN
        CALL LIB$SPAWN('PRINT P1.REN')
      ENDIF
      GO TO 41
      ENDIF
C ************
      IF (GRAPHOPT .EQ. 2) THEN
       CALL GRAPH2
C    GET A HARDCOPY OF THIS GRAPHIC
       CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
     +SIZE=A P2.UIS')
      CALL LIB$SPAWN('CONTINUE')
      PRINT *, ' '
      PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
      PRINT *, ' '
      READ 1002, PLOT2
      IF (PLOT2.EQ.'Y')THEN
        CALL LIB$SPAWN('PRINT P2.REN')
      ENDIF
      GO TO 41
      ENDIF
C ***********
```

```
      IF (GRAPHOPT .EQ. 3) THEN
       CALL GRAPH3
C    GET A HARDCOPY OF THIS GRAPHIC
       CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
     +SIZE=A P3.UIS')
      CALL LIB$SPAWN('CONTINUE')
      PRINT *, ' '
      PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
      PRINT *, ' '
      READ 1002, PLOT3
      IF (PLOT3.EQ.'Y')THEN
        CALL LIB$SPAWN('PRINT P3.REN')
      ENDIF
      GO TO 41
      ENDIF
C *************
      IF (GRAPHOPT .EQ. 4) THEN
       CALL GRAPH4
C    GET A HARDCOPY OF THIS GRAPHIC
       CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
     +SIZE=A P4.UIS')
      CALL LIB$SPAWN('CONTINUE')
      PRINT *, ' '
      PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
      PRINT *, ' '
      READ 1002, PLOT4
      IF (PLOT4.EQ.'Y')THEN
        CALL LIB$SPAWN('PRINT P4.REN')
      ENDIF
      GO TO 41
      ENDIF
C *************
      IF (GRAPHOPT .EQ. 5) THEN
       CALL GRAPH5
C    GET A HARDCOPY OF THIS GRAPHIC
       CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
     +SIZE=A P5.UIS')
      CALL LIB$SPAWN('CONTINUE')
      PRINT *, ' '
      PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
      PRINT *, ' '
      READ 1002, PLOT5
      IF (PLOT5.EQ.'Y')THEN
        CALL LIB$SPAWN('PRINT P5.REN')
      ENDIF
      GO TO 41
      ENDIF
C *************
      IF (GRAPHOPT .EQ. 6) THEN
       PRINT *, ' THE SELECTED NUMBER OF HORSESHOE VORTICES HAVE'
       PRINT *, ' BEEN EVENLY SPACED ACROSS THE SEMISPAN AND THE'
       PRINT *,' FIRST VORTEX IS NEAR THE WING TIP.'
       PRINT *, ' '
       PRINT *, '  AT WHICH HORSESHOE VORTEX WOULD YOU LIKE TO'
       PRINT *, '    SEE THE CHORDWISE DELTA CP DISTRIBUTION?'
       PRINT 922, VIC
      PRINT *, ' '
922   FORMAT(3X,'     ENTER A NUMBER BETWEEN 1 AND',F4.0)
 68   READ 1008, NUMVOR
1008  FORMAT(I3)
      IF (NUMVOR .LT. 0. .OR. NUMVOR .GT. VIC) THEN
        PRINT *, ' '
        PRINT *, '       INVALID ENTRY.TRY AGAIN.'
        PRINT *, ' '
        PRINT *, ' REMEMBER THAT THE VORTICES ARE SPREAD'
        PRINT *, ' EVENLY ACROSS THE SEMISPAN AND THE 1ST'
        PRINT *, ' VORTEX IS NEAR THE WING TIP.'
        PRINT *, ' '
        GO TO 68
      ENDIF
        PRINT *, 'GRAPHICS BEING CREATED'
      CALL GRAPH6(NUMVOR)
C    GET A HARDCOPY OF THIS GRAPHIC
      CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
     +SIZE=A P6.UIS')
      CALL LIB$SPAWN('CONTINUE')
      PRINT *, ' '
      PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
      PRINT *, ' '
      READ 1002, PLOT6
      IF (PLOT6.EQ.'Y')THEN
        CALL LIB$SPAWN('PRINT P6.REN')
      ENDIF
      GO TO 41
      ENDIF
      ENDIF
 1006 FORMAT(I1)
C ************* OPTION TO MAKE ANOTHER RUN ***************
      PRINT *
      PRINT *, 'DO YOU WISH TO :  '
      PRINT *, '      1) MAKE ANOTHER RUN OR'
      PRINT *, '      2) END THIS SESSION'
      PRINT *, '  ENTER 1 OR 2.'
      PRINT *
      CALL QUERY (NANS)
      CALL CLRSCRN
      CLOSE (UNIT = 11)
      CLOSE (UNIT = 12)
      CLOSE (UNIT = 13)
      IF (NANS .EQ. 1) GO TO 1
 999  STOP
      END

      SUBROUTINE AERO
C
      REAL MACH
      DIMENSION CPM(2),YCP(2),YY(2),VOU(300,2),UOU(300,2),FU(2),FV(2),
     1XTLEG(60),CHLFT(300,2),CLCC(300,2),YTLEG(50),SLDT(50),CLA(2),SUM(2
     2),AC(2),CH(2,50),CCAV(2,50),CLCL(2,50), CP(120),FW(2)
     3,DIFCIRS(25),YLEGSV(25),ZLEGSV(25),CLPT(300,2),CLPB(300,2)
      COMMON/ALL/ BOT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(300),PN(300),
     1           PV(300),ALP(300),S(300),PSI(300),PHI(300),ZH(50)
```

```
      COMMON/TOTHRE/ CIR(300,2),SECTRST(50)
      COMMON/ONETHRE/TWIST(2),CREF,SREF,CAVE,CLDES,STRUE,AR,ARTRUE,
     1   RTCDHT(2),CONFIG,NSSWSV(2),MSV(2),KBOT,PLAN,IPLAN,MACH
     2   ,SSWWA(50)
      COMMON /PLT1/NSSW
      COMMON/THRECDI/SLOAD(3,50)
      COMMON/INSUB23/APSI,APHI ,XX ,YYY,ZZ ,SNN,TOLCSQ
      CHARACTER*8 HEAD
    1 FORMAT (/ 12X, 'SECOND PLANFORM HORSESHOE VORTEX DESCRIPTIONS' / )
    3 FORMAT(6F12.5)
    4 FORMAT (   ///58X,16HAERODYNAMIC DATA,///54X,      'CONFIGURATION
     1NO.',F7.0 // )
    5 FORMAT(///18X,'COMPLETE CONFIGURATION',31X,'WING-BODY CHARACTERIST
     1ICS',/ 64X,'LIFT', 9X,'INDUCED DRAG (FAR FIELD SOLUTION)',//
     2 16X, A8,' CL    COMPUTED ALPHA',19X,'CL(WB)',7X,'CDI AT CL(WB)',
     3 4X ,15HCDI/(CL(WB)**2),/ 88X,12H(1/(PI*AR) =,F8.5,' )'  )
    6 FORMAT (11X,2F15.5,15X,3F15.5)
    7 FORMAT(////4X,11H REF. CHORD,6X,25HC AVERAGE  TRUE WING AREA,3X,13
     1HREF WING AREA,9X,3HB/2, 8X,7HREF. AR,8X,7HTRUE AR,4X,11HMACH NUMB
     2ER/)
    8 FORMAT(8F15.5)
   11 FORMAT (/// 47X,'COMPLETE CONFIGURATION CHARACTERISTICS',//
     1 36X,'CL ALPHA',8X,'CL(TWIST)  ALPHA AT CL=0    Y CP      CM/CL
     2    CMO',/ 27X,'PER RADIAN   PER DEGREE',/ 24X,7F12.5 )
   12 FORMAT(//25X,'ADDITIONAL LOADING AT',/23X,'L(TOTAL)/(Q*S(TRUE)) =
     11.0',/67X,'LOAD DUE   ADD. LOAD AT  BASIC LOAD',2X,'SPAN LOAD AT
     2 SL COEF FROM',/' STATION',6X,' 2Y/B',9X,'S L COEF.',4X,'CL RATIO'
     3,4X,'C RATIO',7X,'TO TWIST   CL=',F9.5,3X,'AT CL=0',5X,'DESIRED CL
     4    CHORD BD VOR'/)
   13 FORMAT (/ 47X, 'CONTRIBUTION OF THE SECOND PLANFORM TO SPAN LOAD D
     1ISTRIBUTION' / )
   15 FORMAT(4X,I4,F12.5,5X,3F12.5,3X,3F12.5,3X,2F12.5)
   16 FORMAT (1H )
   18 FORMAT(////55X,21HTHIS CASE IS FINISHED)
   20 FORMAT(///5X,'DELTA CP TERMS FROM LE TIP TO TE TIP THEN INBOARD
     1 ENDING WITH THE TE OF ROOT CHORD ')
   21 FORMAT (     /54X,'CMQ AND CLQ ARE COMPUTED'//)
   22 FORMAT(/38X,'STATIC LONGITUDINAL AERODYNAMIC COEFFICIENTS ARE COMP
     1UTED'//)
   23 FORMAT (    /59X,'CLP IS COMPUTED'//)
   24 FORMAT(8F15.5)
   25 FORMAT (/20X,'X',11X,'X',11X,'Y',11X,'Z',12X,'S',5X,'C/4 SWEEP',4X
     1 ,'DIHEDRAL',2X,'LOCAL ALPHA',2X,'DELTA CP AT DESIRED' /
     2 19X,'C/4',9X,'3C/4',42X,'ANGLE',7X,'ANGLE',4X,'IN RADIANS',4X,
     3  'CL =',F10.5  / )
  303 FORMAT(12X,9F12.5)
 1013 FORMAT(/47X,'CONTRIBUTION OF THE SECOND PLANFORM TO THE CHORD OR D
     1RAG FORCE'/)
 1070 FORMAT  (////  30X, 'INDUCED DRAG, LEADING EDGE THRUST AND SUCTION
     1 COEFFICIENT CHARACTERISTICS',/
     2 34X,'COMPUTED AT ONE RADIAN ANGLE OF ATTACK FROM A NEAR FIELD SOL
     3UTION'  ,//
     4 58X,'SECTION COEFFICIENTS',12X,'CONTRIBUTIONS TO TOTAL COEF.',/
     5 92X,'FROM EACH SPANWISE ROW',/
     6 38X,'L. E. SWEEP',/
     7 15X,'STATION',9X,' 2Y/B',5X,'ANGLE',5X,'CDII C/2B',5X,'CT C/2B',
     8 5X,'CS C/2B',6 ,'CDII',9X,'CT',10X,'CS'/)
 1071 FORMAT  (10X ,I10, 5X, 8F12.5)
 1072 FORMAT  (/// 57X,'TOTAL COEFFICIENTS',//
     1 36X,12HCDII/CL**2 =  ,F10.5 ,5X,'CT=',F10.5,5X,'CS=',F10.5 )
 4445 FORMAT(//////////56X,4HCLP=,F9.5////)
 4446 FORMAT(//////////42X,4HCMQ=,F9.5,10X,4HCLQ=,F9.5////)
      METH = 0
      MORT = 0
C
C
C
C
C     PART 3 - COMPUTE OUTPUT TERMS
C
C
C
      RAD = 57.29578
      TWST    = TWIST(1) + TWIST(2)
      ALREF   = 1
C
C
C     THE TOLERANCE SET AT THIS POINT IN THE PROGRAM MAY NEED TO BE
C     CHANGED FOR COMPUTERS OTHER THAN THE CDC 6000 SERIES
C
C
      TOLC= .0100*BOT
      TOLCSQ = TOLC*TOLC
      QINF=1.
      NSSW=NSSWSV(1)+NSSWSV(2)
      IF(RTCDHT(1).NE.RTCDHT(2)) GO TO 794
      SUMPHI=0
      DO 801 J=1,NSSW
  801 SUMPHI=SUMPHI+ABS(PHI(J))
      IF(SUMPHI.EQ.0.) GO TO 921
C
C                          PART 3 - SECTION 1
C         COMPUTE LIFT AND PITCHING MOMENT FOR WINGS WITH DIHEDRAL
C
C     GEOMETRY FOR TIP TRAILING LEGS
C
  794 CPM(1) =  0
      CPM(2) =  0
      YCP(1) =  0
      YCP(2) =  0
      IM     =  0
      CLT    =  0
      CLNT   =  0
      NSSW1  =  0
      NSSW2  =  NSSWSV(1)
      NSSW3  =  NSSWSV(1)
      L=1
      NSCW  =  MSV(1) / NSSWSV(1)
      GO TO 798
  796 NSSW1  =  NSSWSV(1)
      NSSW2  =  NSSW
      NSSW3  =  NSSWSV(2)
      L=NSSWSV(1)+1
      NSCW  =  MSV(2) / NSSWSV(2)
  798 I  =  IM + 1
      J  =  IM + 2
      IUU=2
      DIFFCR1=0.
      APHI=ATAN(PHI(I))
      TLX1=PN(I)-S(I)*TAN(PSI(I))
      TLX2=PN(J)-S(J)*TAN(PSI(J))
      CLFTLG=TLX1-TLX2
      XTLEG(1)=TLX1/2.+TLX2/2.
      YLEG=Q(I)-S(I)*COS(APHI)
      IF(NSSW1.EQ.0) YLEGSV(  1)=YLEG
      ZLEG=ZH(I)-S(I)*SIN(APHI)
      IF(NSSW1.EQ.0) ZLEGSV( 1 )=ZLEG
      IF(NSSW1.EQ.NSSWSV(1)) GO TO 850
      GO TO 852
  850 DO 5050 IT=1,L
      IF((ABS(YLEGSV(IT)-YLEG).LT.TOLC).AND.(ABS(ZLEGSV(IT)-ZLEG).LT.TOL
     1C)) DIFFCR1=DIFCIRS(IT)
 5050 CONTINUE
  852 DO 802 NV=2,NSCW
      NVT=NV-1
  802 XTLEG(NV)=XTLEG(NVT)-CLFTLG
      NCTL=0
      NA  =1
      NB  =NSCW
  803 DO 823 NV=NA,NB
      VOU(NV,1)= 0
      VOU(NV,2)= 0
      UOU(NV,1)= 0
      UOU(NV,2)= 0.
      DO 809 NN=1,M
      IZ=(NN-1)/NSCW+1
      APHI=ATAN(PHI(IZ))
      APSI=PSI(NN)
      XX=XTLEG(NV)-PN(NN)
      YY(1)=YLEG-Q(NN)
      YY(2)=YLEG+Q(NN)
      ZZ=ZLEG -ZH(IZ)
      SNN   =  S(NN)
C
      DO 822 I=1,2
      YYY   = YY(I)
      CALL INFSUB (BOT,FU(I),FV(I),FW(I) )
      APHI=-APHI
      APSI=-APSI
  822 CONTINUE
C
 9001 DO 809 IXX=1,2
      UOU(NV,IXX)=UOU(NV,IXX)+((FU(1)+FU(2))*CIR(NN,IXX))/12.566371
  809 VOU(NV,IXX)=VOU(NV,IXX)+((FV(1)+FV(2))*CIR(NN,IXX))/12.566371
  823 CONTINUE
      NCTL=NCTL+1
      IF (NCTL-2)    810,811,812
C
```

```
C     GEOMETRY FOR SPANWISE BOUND VORTICES
C
  810 NA=NSCW+1
      NB=2*NSCW
      JA=IM*NSCW+1
      YLEG=Q(JA)
      ZLEG=ZH(IM+1)
      DO 818 J=1,NSCW
      JK=IM*NSCW+J
      NV=J+NSCW
  818 XTLEG(NV)=PN(JK)
      GO TO 803
C
C     GEOMETRY ALONG RIGHT TRAILING LEGS
C
  811 NA=2*NSCW+1
      NB=3*NSCW
      DIFFCR2=0.
      JK=IM*NSCW+1
      APHI=ATAN(PHI(IM+1))
      YLEG=Q(JK)+S(JK)*COS(APHI)
      IF(NSSW1.EQ.0) YLEGSV(IUU)=YLEG
      ZLEG=ZH(IM+1)+S(JK)*SIN(APHI)
      IF(NSSW1.EQ.0) ZLEGSV(IUU)=ZLEG
      TLX1=PN(JK)+S(JK)*TAN(PSI(JK))
      JK=JK+1
      TLX2=PN(JK)+S(JK)*TAN(PSI(JK))
      CRTTLG=TLX1-TLX2
      XTLEG(NA)=TLX1/2.+TLX2/2.
      NAA=NA+1
      IF(NSSW1.EQ.NSSWSV(1)) GO TO 851
      GO TO 853
  851 DO 5051 IT=1,L
      IF((ABS(YLEGSV(IT)-YLEG).LT.TOLC).AND.(ABS(ZLEGSV(IT)-ZLEG).LT.TOL
     1C)) DIFFCR2=DIFCIRS(IT)
 5051 CONTINUE
  853 DO 819 NV=NAA,NB
      NVT=NV-1
  819 XTLEG(NV)=XTLEG(NVT)-CRTTLG
      GO TO 803
C
C     COMPUTE LIFT AND PITCHING MOMENT FOR EACH ELEMENTAL PANEL
C
  812 YY(1)=0
      YY(2)=0
      IF ( IM.NE.NSSW1 ) GO TO 834
      DO 835 IXX=1,2
      DIFCIR=DIFFCR1
      DO 835 NPOS=1,NSCW
      DIFCIR=DIFCIR+CIR(NPOS,IXX)
      CON=1.
      MORT = MORT + 1
      IF (NPOS.EQ.NSCW)   CON=.75
      CHLFT(NPOS,IXX)=CLFTLG*CON*DIFCIR*VOU(NPOS,IXX)*(2./SREF)
      CLPT(NPOS,IXX)=CHLFT(NPOS,IXX)*(Q(NPOS)-S(NPOS))*2.
  835 CONTINUE
```

```
      IF(NSSW1.EQ.0) DIFCIRS( 1 )=DIFCIR
  834 DO 815 IXX=1,2
      DIFCIR=DIFFCR2
      DO 815 NPOS=1,NSCW
      JK=IM*NSCW+NPOS
      JL=(IM+1)*NSCW+NPOS
      JM=NSCW+NPOS
      JN=2*NSCW+NPOS
      IF (IM.EQ.(NSSW2-1))  GO TO 836
      DIFCIR=DIFCIR+CIR(JL,IXX)-CIR(JK,IXX)
  836 CON=1.
      IF (NPOS.EQ.NSCW)  CON=.75
      CHLFT(JL,IXX)=CRTTLG*CON*DIFCIR*VOU(JN,IXX)*(2./SREF)
      CLCC(JK,IXX)=(2./SREF)*CIR(JK,IXX)*2.*S(JK)*COS(APHI)* (1.-UOU(JM,
     1IXX)+VOU(JM,IXX)*TAN(PSI(JK)))
      CLPB(JK,IXX)=CLCC(JK,IXX)*Q(JK)*2.
      CLPT(JL,IXX)=CHLFT(JL,IXX)*(Q(JK)+S(JK))*2.
      YY(IXX)=YY(IXX)+(CLCC(JK,IXX)+CHLFT(JK,IXX))*2.
      CPM(IXX)=CPM(IXX)+(CLCC(JK,IXX)*XTLEG(JM)*BETA+CHLFT(JK,IXX)*XTLEG
     1(NPOS)*BETA)*2./CREF
      YCP(IXX)=YCP(IXX)+(CLCC(JK,IXX)*Q(JK)+CHLFT(JK,IXX)*(Q(JK)-S(JK)*
     1COS(APHI)))/BOT
  815 CONTINUE
      IF(NSSW1.EQ.0) DIFCIRS(IUU)=DIFCIR
      CLT=CLT+YY(1)
      CLNT=CLNT+YY(2)
      IM=IM+1
      IF(NSSW1.EQ.0) IUU=IM+2
      IF(IM.EQ.NSSWSV(1)) CLWNGT=CLT
      IF(IM.EQ.NSSWSV(1)) CLWING=CLNT
      IF (IM.GE.NSSW2)      GO TO 816
      NCTL=1
      DO 817 IXX=1,2
      DO 817 NV =1,NSCW
      NY=NV+2*NSCW
      XTLEG(NV)=XTLEG(NY)
  817 VOU(NV,IXX)=VOU(NY,IXX)
      GO TO 810
C
C        SUM LIFT AND PITCHING MOMENT FOR ENTIRE WING
C
  816 YY(1)=CLT*SREF/STRUE
      YY(2)=CLNT*SREF/STRUE
      NUP=NSSW3 + 1
      YTLEG(NUP)=0.
      XTLEG(NUP)=0
      IND=1
      IF (TWST .EQ.0.)  IND=2
      DO 837 IXX=IND,2
      DO 820 JSSW=L,NSSW2
      SLOAD(IXX,JSSW)=0
      SLDT(    JSSW)=0
      APHI=ATAN(PHI(JSSW))
      JL=(JSSW-1)*NSCW+1
      K=JSSW-L+1
  820 YTLEG( K  )=Q(JL)-S(JL)*COS(APHI)
```

```
      DO 837 INC=1,NSCW
      DO 838 JNS=L,NSSW2
      JK=(JNS-1)*NSCW+INC
      K=JNS-L+1
  838 XTLEG( K )=CHLFT(JK,IXX)
      DO 837 INS=L,NSSW2
      JK=(INS-1)*NSCW+INC
      APHI=ATAN(PHI(INS))
      CALL FTLUP (Q(JK),CHTLF,+1,NUP,YTLEG,XTLEG)
      T= SREF/(2.*S(JK)*COS(APHI)*CAVE)
      SLDT(INS)=SLDT(INS)+CHTLF*T
      CLCC(JK,IXX) = (CLCC(JK,IXX) + CHTLF ) * T
  837 SLOAD(IXX,INS)=SLOAD(IXX,INS)+ CLCC(JK,IXX)
      IF (IM.NE.NSSW)  GO TO 796
      CLA(2)=CLNT /ALREF
      CMCL=CPM(2)/CLNT
      CMO=CPM(1)-CMCL*CLT
      YCP(2)=YCP(2)/(CLNT/2.)
      DO 840 I=1,NSSW
      SLDT(I)=SLDT(I)/YY(2)
      IF (TWST .EQ.0.)  SLOAD(1,I)=0.
      IF (TWST .NE.0.)  SLOAD(1,I)=SLOAD(1,I)/YY(1)
  840 SLOAD(2,I) = SLOAD(2,I)/YY(2)
      CRL=0.
      DO 860 IAM=1,M
  860 CRL=CRL+CLPB(IAM,2)+CLPT(IAM,2)
      CLP=CRL/(.08725*2.*BOT)
      GO TO 903
C
C                          PART 3 - SECTION 2
C         COMPUTE LIFT AND PITCHING MOMENT FOR WINGS WITHOUT DIHEDRAL
C
  921 DO 901 NV=1,2
      SUM(NV)=0
      DO 901 I=1,M
      SUM(NV)=SUM(NV)+CIR(I,NV)*S(I)
      IF (NV.EQ.1.AND.I.EQ.MSV(1) )    CLWNGT = SUM(1)*8.  / SREF
      IF (NV.EQ.2.AND.I.EQ.MSV(1) )    CLWING = SUM(2)*8.  / SREF
  901 CONTINUE
      CLT     = 8.* SUM(1)/SREF
      CLNT    = 8.* SUM(2)/SREF
      IF (KBOT.EQ.1)                    GO TO 800
      CLWNGT = CLT - CLWNGT
      CLWING = CLNT- CLWING
  800 CRL     = 0.
      DO 905 I=1,M
      CRL=CRL+(Q(I)*CIR(I,2)*2.*S(I))*2.
      CLCC(I,1)=CIR(I,1)*2./CAVE
  905 CLCC(I,2)=CIR(I,2)*2./CAVE
C
C     COMPUTE CLP
C
      CLP=   CRL/(SREF*BOT*0.08725)
      CLA(2)=CLNT
      DO 922 IXX=1,2
      SA = 0
      SB = 0
      SC = 0.
      I     = 0
      DO 920 JSSW=1,NSSW
      SLDT(JSSW)=0
      SLOAD(IXX,JSSW)=0
      NSCW   = TBLSCW(JSSW)
      DO 920 JSCW=1,NSCW
      IF(TWST .EQ.0..AND.IXX.EQ.1) GO TO 930
      I     = I + 1
      SA=SA+CIR(I,IXX)*S(I)
      SB=SB+CIR(I,IXX)*Q(I)*S(I)
      SC=SC+CIR(I,IXX)*PN(I)*S(I)*BETA
      SLOAD(IXX,JSSW) = SLOAD(IXX,JSSW)+(BOT*CIR(I,IXX))/(2.*SUM(IXX))
      GO TO 920
  930 SLOAD(1,JSSW)=0.
  920 CONTINUE
      IF(TWST .EQ.0..AND.IXX.EQ.1) GO TO 932
      YCP(IXX)=SB/(SA*BOT)
      AC(IXX)=SC/(SA*CREF)
      GO TO 922
  932 YCP(1)=0
      AC(1) =0.
  922 CONTINUE
      CMCL=AC(2)
      CMO=(AC(1)-AC(2))*CLT
C
C                         PART 3 - SECTION 3
C           COMPUTE AND PRINT FINAL OUTPUT DATA FOR ALL WINGS
C
  903 DO 902 IXX=1,2
      JN      = 0
      DO 902 JSSW=1,NSSW
      CH    (IXX,JSSW)=0
      NSCW    = TBLSCW(JSSW)
      DO 904 JSCW=1,NSCW
      JN      = JN + 1
      CH    (IXX,JSSW)=(-2.0)*(PV(JN)-PN(JN))*BETA+CH    (IXX,JSSW)
  904 CONTINUE
      CCAV(IXX,JSSW)=CH(IXX,JSSW)/CAVE
      CLCL(IXX,JSSW)=SLOAD(IXX,JSSW)/CCAV(IXX,JSSW)
  902 CONTINUE
      CLD=CLDES
      IF(CLDES.EQ.11) CLD=1.
      DO 1020 I=1,M
      CP(I)    = (CLCC(I,1)+CLCC(I,2)*(CLD  -CLT)/CLNT)*CAVE/(2.*(PN(I)-
     1            PV(I) ) * BETA )
 1020 CONTINUE
      WRITE (29,4)  CONFIG
      IF  ( PTEST.NE.0. )                      WRITE (29,23)
      IF  ( QTEST.NE.0. )                      WRITE (29,21)
      IF  ( PTEST.EQ.0. .AND.  QTEST.EQ.0. )   WRITE (29,22)
      WRITE(29,25) CLD
      HEAD = ' DESIRED'
      IF (CLDES.EQ.11. )    HEAD = '        '
      IEND = 11
      IF(CLDES.NE.11.) IEND=1
      DO 5000 IUTK=1,IEND
      IF(IEND.EQ.11) CLDES=(FLOAT(IUTK)-1.)/10.
      IF(CLDES.EQ.0.) CLDES=-.1
      NR      = 0
C      MORT = MORT + 1
      DO 3006 NV=1,NSSW
      NSCW    = TBLSCW(NV)
      NP      = NR + 1
      NR      = NR + NSCW
      PHIPR  =  ATAN(PHI(NV)) * RAD
      SLOAD(3,NV)=0.
      IF (NV.EQ.(NSSWSV(1)+1).AND.IUTK.EQ.1) WRITE (29,1)
      METH = METH + 1
      DO 3006 I=NP,NR
      IF ( IUTK.GT.1 )                  GO TO 3006
      PNPR  = PN(I) * BETA
      PVPR  = PV(I) * BETA
      PSIPR = PSI(I)* RAD
      WRITE(29,303) PNPR,PVPR,Q(I),ZH(NV),S(I),PSIPR,PHIPR,ALP(I),CP(I)
      WRITE(13,603) METH,MORT,PNPR,PVPR,Q(I),CP(I)
  603 FORMAT(1X,2I3,4F12.5)
C      MORT = MORT + 1
C      METH = METH + 1
 3006 SLOAD(3,NV)=SLOAD(3,NV)+CLCC(I,2)*CLDES/CLNT+CLCC(I,1)-CLCC(I,2)*C
     1LT/CLNT
      IF(IUTK.GT.1) GO TO 3007
      WRITE(29,7)
      WRITE(29,8) CREF,CAVE,STRUE,SREF, BOT,AR,ARTRUE,MACH
 3007 CONTINUE
C
C
      IF(PTEST.NE.0.)WRITE(29,4445) CLP
      IF(PTEST.NE.0.) GO TO 4444
C
C     COMPUTE CMQ,CLQ
C
      CMQ=2.0*CMCL*CLNT/(0.08725*CREF)
      CLQ=2.0*CLNT/(0.08725*CREF)
      IF(QTEST.NE.0.) WRITE(29,4446) CMQ,CLQ
      IF(QTEST.NE.0.) GO TO 4444
C
C           COMPUTE INDUCED DRAG
C
      NSV=NSSWSV(1)+1
      MTOT=MSV(1)+1
      IF(KBOT.EQ.1)                     GO TO 1001
      NSV=NSV+NSSWSV(2)
      MTOT=MTOT+MSV(2)
 1001 CALL CDICLS    (AR,ARTRUE,NSSWSV(KBOT),MTOT,NSV,CDI,CDIT)
      CLAPD=CLA(2)/57.29578
      ALPO=-(CLT/CLA(2))*57.29578
      ALPD=CLDES/CLAPD+ALPO
      ALPW=1./CLAPD
      CLWB=CLWING*ALPD/57.29578+CLWNGT
      CDIWB = CDI /(CLWB*CLWB)
      IF (IUTK.EQ.1)  WRITE (29,5) HEAD,CDIT
 5000 WRITE (29,6) CLDES,ALPD,CLWB,CDI,CDIWB
      WRITE(29,11) CLA(2),CLAPD,CLT,ALPO,YCP(2),CMCL,CMO
      WRITE(29,12) CLT
      NR   = 0
      J    = 0
      DO 1004 NV=1,NSSW
      BCLCC = 0
      BADLAE= 0
      BASLD = 0.
      NSCW     = TBLSCW(NV)
      NP       = NR + 1
      NR       = NR + NSCW
      DO 1002 I=NP,NR
      ADLAE=CLCC(I,2)*CLT/CLNT
      BSLD=CLCC(I,1)-ADLAE
      BCLCC=BCLCC+CLCC(I,1)
      BADLAE=BADLAE+ADLAE
      BASLD=BASLD+BSLD
C       METH = METH + 1
 1002 CONTINUE
C       MORT = MORT + 1
      J        = J + NSCW
      YQ       = Q(J) / BOT
      IF (NV.EQ.(NSSWSV(1)+1))  WRITE(29,13)
      WRITE(12,15) NV,-(YQ),SLOAD(2,NV),CLCL(2,NV),CCAV(2,NV),
     +  BCLCC,BADLAE,BASLD,SLOAD(3,NV),SLDT(NV)
 1004 WRITE(29,15) NV,YQ,SLOAD(2,NV),CLCL(2,NV),CCAV(2,NV),BCLCC,BADLAE,
     1  BASLD,SLOAD(3,NV),SLDT(NV)
      WRITE (29,1070)
      CTHRUST = 0
      CSUCT   = 0
      CDRAG   = 0.
      NN=1
      DO 1050 NV=1,NSSW
      SSCTRST = SECTRST(NV) / (4.*BOT)
      SSCDRAG = SLOAD (2,NV) * CAVE * SREF * CLA(2) / (STRUE * 4.  * BOT)
     1          - SSCTRST
      CSSWWA  = COS ( ATAN (SSWWA(NV)))
      SSCSUCT = SSCTRST      / CSSWWA
      IF (NV.EQ.1)  GO TO 1060
      NN   = NN + TBLSCW(NV-1)
 1060 PHIPR  =  ATAN (PHI(NV))
      CDRAGS  = SSCDRAG*4.*BOT*2.*S(NN)*COS(PHIPR)/SREF
      CDRAG   = CDRAG   + 2.0 * CDRAGS
      CTHRUSS = SECTRST(NV)*2.*S(NN)*COS(PHIPR) / SREF
      CTHRUST = CTHRUST + 2.0 * CTHRUSS
      CSUCTS  = CTHRUSS / CSSWWA
      CSUCT   = CSUCT   + 2.0 * CSUCTS
      SWALE   = ATAN(SSWWA(NV)) * RAD
      YQ      = Q(NN)/ BOT
      IF(NV.EQ.(NSSWSV(1)+1)) WRITE(29,1013)
      WRITE(11,1071) NV,-(YQ),SWALE,SSCDRAG,SSCTRST,SSCSUCT
     +    ,CDRAGS,CTHRUSS,CSUCTS
 1050 WRITE(29,1071) NV,YQ,SWALE,SSCDRAG,SSCTRST,SSCSUCT,CDRAGS,CTHRUSS,
     1               CSUCTS
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```
      CDRAGP  =  CDRAG / (CLA(2)*CLA(2))
      WRITE(29,1072) CDRAGP,CTHRUST,CSUCT
 4444 WRITE(29,18)
      METH = 99
      MORT = 0
      PNPR = 0.00
      PVPR = 0.00
      Q(NR+1) = 0.00
      CP(NR+1)= 0.00
      WRITE(13,603)METH,MORT,PNPR,PVPR,Q(NR+1),CP(NR+1)
      CLOSE(UNIT = 11)
      CLOSE(UNIT = 12)
      CLOSE(UNIT = 13)
      WRITE(29,16)
      RETURN
      END

      SUBROUTINE AMATINV(A,N,B,M,DETERM,IPIVOT,INDEX,NMAX,ISCALE)
C
C********* DOCUMENT DATE 08-01-68   SUBROUTINE REVISED 08-01-68 *********
C
C     MATRIX INVERSION WITH ACCOMPANYING SOLUTION OF LINEAR EQUATIONS
C
      DIMENSION IPIVOT(N),A(NMAX,N),B(NMAX,M),INDEX(NMAX,2)
      EQUIVALENCE (IROW,JROW), (ICOLUM,JCOLUM), (AMAX, T, SWAP)
C
C     INITIALIZATION
C
    5 ISCALE=0
    6 R1=10.0**35
    7 R2=1.0/R1
   10 DETERM=1.0
   15 DO 20 J=1,N
   20 IPIVOT(J)=0
   30 DO 550 I=1,N
C
C     SEARCH FOR PIVOT ELEMENT
C
   40 AMAX=0.0
   45 DO 105 J=1,N
   50 IF (IPIVOT(J)-1) 60, 105, 60
   60 DO 100 K=1,N
   70 IF (IPIVOT(K)-1) 80, 100, 740
   80 IF (ABS(AMAX)-ABS(A(J,K)))85,100,100
   85 IROW=J
   90 ICOLUM=K
   95 AMAX=A(J,K)
  100 CONTINUE
  105 CONTINUE
      IF (AMAX) 110,106,110
  106 DETERM=0.0
      ISCALE=0
      GO TO 740
  110 IPIVOT(ICOLUM)=IPIVOT(ICOLUM)+1
C
```

```
C     INTERCHANGE ROWS TO PUT PIVOT ELEMENT ON DIAGONAL
C
  130 IF (IROW-ICOLUM) 140, 260, 140
  140 DETERM=-DETERM
  150 DO 200 L=1,N
  160 SWAP=A(IROW,L)
  170 A(IROW,L)=A(ICOLUM,L)
  200 A(ICOLUM,L)=SWAP
  205 IF(M) 260, 260, 210
  210 DO 250 L=1, M
  220 SWAP=B(IROW,L)
  230 B(IROW,L)=B(ICOLUM,L)
  250 B(ICOLUM,L)=SWAP
  260 INDEX(I,1)=IROW
  270 INDEX(I,2)=ICOLUM
  310 PIVOT=A(ICOLUM,ICOLUM)
      IF (PIVOT) 1000,106,1000
C
C     SCALE THE DETERMINANT
C
 1000 PIVOTI=PIVOT
 1005 IF(ABS(DETERM)-R1)1030,1010,1010
 1010 DETERM=DETERM/R1
      ISCALE=ISCALE+1
      IF(ABS(DETERM)-R1)1060,1020,1020
 1020 DETERM=DETERM/R1
      ISCALE=ISCALE+1
      GO TO 1060
 1030 IF(ABS(DETERM)-R2)1040,1040,1060
 1040 DETERM=DETERM*R1
      ISCALE=ISCALE-1
      IF(ABS(DETERM)-R2)1050,1050,1060
 1050 DETERM=DETERM*R1
      ISCALE=ISCALE-1
 1060 IF(ABS(PIVOTI)-R1)1090,1070,1070
 1070 PIVOTI=PIVOTI/R1
      ISCALE=ISCALE+1
      IF(ABS(PIVOTI)-R1)320,1080,1080
 1080 PIVOTI=PIVOTI/R1
      ISCALE=ISCALE+1
      GO TO 320
 1090 IF(ABS(PIVOTI)-R2)2000,2000,320
 2000 PIVOTI=PIVOTI*R1
      ISCALE=ISCALE-1
      IF(ABS(PIVOTI)-R2)2010,2010,320
 2010 PIVOTI=PIVOTI*R1
      ISCALE=ISCALE-1
  320 DETERM=DETERM*PIVOTI
C
C     DIVIDE PIVOT ROW BY PIVOT ELEMENT
C
  330 A(ICOLUM,ICOLUM)=1.0
  340 DO 350 L=1,N
  350 A(ICOLUM,L)=A(ICOLUM,L)/PIVOT
  355 IF(M) 380, 380, 360
  360 DO 370 L=1,M
  370 B(ICOLUM,L)=B(ICOLUM,L)/PIVOT
C
C     REDUCE NON-PIVOT ROWS
C
  380 DO 550 L1=1,N
  390 IF(L1-ICOLUM) 400, 550, 400
  400 T=A(L1,ICOLUM)
  420 A(L1,ICOLUM)=0.0
  430 DO 450 L=1,N
  450 A(L1,L)=A(L1,L)-A(ICOLUM,L)*T
  455 IF(M) 550, 550, 460
  460 DO 500 L=1,M
  500 B(L1,L)=B(L1,L)-B(ICOLUM,L)*T
  550 CONTINUE
C
C     INTERCHANGE COLUMNS
C
  600 DO 710 I=1,N
  610 L=N+1-I
  620 IF (INDEX(L,1)-INDEX(L,2)) 630, 710, 630
  630 JROW=INDEX(L,1)
  640 JCOLUM=INDEX(L,2)
  650 DO 705 K=1,N
  660 SWAP=A(K,JROW)
  670 A(K,JROW)=A(K,JCOLUM)
  700 A(K,JCOLUM)=SWAP
  705 CONTINUE
  710 CONTINUE
  740 RETURN
      END

      SUBROUTINE CDICLS    (AR,ARTRUE,ISEMSP,MTOT,NSV,CDI,CDIT)
C
      DIMENSION ETAN(51),GAMPR(51,1),ETA(41),GAMMA(41),VE(41),B(41),
     1FVN(41,41)
      COMMON/ALL/ BOT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(300),PN(300),
     1     CASEFN,PV(300),ALP(300),S(300),PSI(300),PHI(300),ZH(50)
      COMMON/THRECDI/SLOAD(3,50)
      CHARACTER*20 CASEFN
      DO 15 I=1,41
      DO 15 J=1,41
   15 FVN(I,J)=0
      SPAN=2.*BOT
      CAVB=SPAN/ARTRUE
      PI=.314159265E+01
      NST=ISEMSP+1
      NN=MTOT
      DO 101 N=1,ISEMSP
      NM=NSV - N
      NSCW=TBLSCW(NM)
      NN=NN-NSCW
      ETAN(N)=ASIN(-Q(NN)*2./SPAN)
      GAMPR(N,1)=SLOAD(3,NM)*CAVB/(2.*SPAN)
  101 CONTINUE
      ETAN(NST)= PI/2.
      GAMPR(NST,1)=0
      DO 7 NP= 1,41
      ANP=NP
    7 ETA(NP)=    (ANP-21.)*PI/42.
C
      DO 102 JK=21,41
      CALL FTLUP(ETA(JK),GAMMA(JK),1,NST,ETAN,GAMPR)
  102 CONTINUE
      DO 600 NY=22,41
      ETA(NY)=SIN(ETA(NY))
      NR=42-NY
      ETA(NR)=-ETA(NY)
  600 GAMMA(NR)=GAMMA(NY)
      DO 589 NU=21,41
      ANU=NU
      DO 14 N=1,41
      AN=N
      NNUD=IABS(N-NU)
      VE(N)=COS(((AN-21.)*PI)/42.)
      IF(NNUD.NE.0) GO TO 9
      B(N)=(42.)/(4.0*COS(((ANU-21.)*PI)/42.))
      GO TO 14
    9 IF(MOD(NNUD,2).EQ.0) GO TO 12
      B(N)=VE(N)/((42.)*(ETA(N)-ETA(NU))**2)
      GO TO 14
   12 B(N)=0.0
   14 CONTINUE
      DO 589 NP=21,41
      NUST =IABS(NU-21)
      IF(NUST.EQ.0) GO TO 589
      IF(MOD(NUST,2).EQ.0) GO TO 589
      NPST=IABS(NP-20)
      IF(MOD(NPST,2).EQ.0) GO TO 589
      NPNUD=IABS(NP-NU)
      IF(NPNUD.EQ.0) GO TO 589
      IF(MOD(NPNUD,2).EQ.0) GO TO 589
      FVN(NU,NP)=2.0*B(NP)/21.*COS((ANU-21.)*PI/42.)
      IT=42-NU
      ITT=42-NP
      FVN(NU,ITT)=2.0*B(ITT)/21.*COS((ANU-21.)*PI/42.)
      FVN(IT,NP)=FVN(NU,ITT)
      FVN(IT,ITT)=FVN(NU,NP)
  589 CONTINUE
C
      CCC=0.0
      DO 10 N=1,41
   10 CCC=CCC+(GAMMA(N)*GAMMA(N))
      CCD=0.0
      DO 11 NUP=1,41
      DO 11 N=1,41
      CCD=CCD-2.0*FVN(NUP,N)*(GAMMA(NUP)*GAMMA(N))
   11 CONTINUE
      CDI=PI*AR/4.*(CCC+CCD)
      CDIT=1./(PI*AR)
      RETURN
      END
      SUBROUTINE CLRSCRN
C
C  LIBRARY ROUTINE TO CLEAR THE SCREEN.
C
      ISTAT = LIB$ERASE_PAGE (1,1)
      RETURN
      END

      SUBROUTINE FTLUP (X,Y,M,N,VARI,VARD)
C
C*********DOCUMENT DATE 09-12-69    SUBROUTINE REVISED 07-07-69 *********
C*       MODIFICATION OF LIBRARY INTERPOLATION SUBROUTINE  FTLUP
      DIMENSION VARI(1),VARD(1),V(3),YY(2)
      DIMENSION II(43)
C*
C*     INITIALIZE ALL INTERVAL POINTERS TO -1.0   FOR MONOTONICITY CHECK
      DATA (II(J),J=1,43)/43*-1/
      MA=IABS(M)
C*
C*            ASSIGN INTERVAL POINTER FOR GIVEN VARI TABLE
C*     THE SAME POINTER WILL BE USED ON A GIVEN VARI TABLE EVERY TIME
      LI = 1
      I=II(LI)
      IF (I.GE.0) GO TO 10
      IF (N.LT.2) GO TO 10
C*
C*MONOTONICITY CHECK
      IF (VARI(2)-VARI(1)) 1,1,3
C* ERROR IN MONOTONICITY
    2 K  =  1
      WRITE(29,102)J,K,(VARI(J),J=1,N),(VARD(J),J=1,N)
  102 FORMAT (1H1,' TABLE BELOW OUT OF ORDER FOR FTLUP  AT POSITION  '
     1,I5,/' X TABLE IS STORED IN LOCATION ',O6,//(8G15.8))
      STOP
C* MONOTONIC DECREASING
    1 DO 5 J=2,N
      IF (VARI(J)-VARI(J-1))5,2,2
    5 CONTINUE
      GO TO 10
C* MONOTONIC INCREASING
    3 DO 6 J=2,N
      IF (VARI(J)-VARI(J-1))2,2,6
    6 CONTINUE
C*
C*INTERPOLATION
   10 IF (I.LE.0) I=1
      IF (I.GE.N) I=N-1
      IF (N.LE.1) GO TO 8
      IF (MA.NE.0) GO TO 99
C* ZERO ORDER
    8 Y=VARD(1)
      GO TO 800
C* LOCATE I INTERVAL (X(I).LE.X.LT.X(I+1))
   99 IF ((VARI(I)-X)*(VARI(I+1)-X)) 61,61,40
C* IN GIVES DIRECTION FOR SEARCH OF INTERVALS
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```
   40 IN=SIGN(1.0,(VARI(I+1)-VARI(I))*(X-VARI(I)))
C* IF X OUTSIDE ENDPOINTS, EXTRAPOLATE FROM END INTERVAL
   41 IF ((I+IN).LE.0) GO TO 61
      IF ((I+IN).GE.N) GO TO 61
      I=I+IN
      IF ((VARI(I)-X)*(VARI(I+1)-X)) 61,61,41
   61 IF (MA.EQ.2) GO TO 200
C*
C*FIRST ORDER
      Y=(VARD(I)*(VARI(I+1)-X)-VARD(I+1)*(VARI(I)-X))/(VARI(I+1)-VARI(I)
     1   )
      GO TO 800
C*
C*SECOND ORDER
  200 IF (N.EQ.2) GO TO 2
      IF (I.EQ.(N-1)) GO TO 209
      IF (I.EQ.1) GO TO 201
C* PICK THIRD POINT
      SK= VARI(I+1)-VARI(I)
      IF ((SK*(X-VARI(I-1))).LT.(SK*(VARI(I+2)-X))) GO TO 209
  201 L=I
      GO TO 702
  209 L=I-1
  702 V(1)=VARI(L)-X
      V(2)=VARI(L+1)-X
      V(3)=VARI(L+2)-X
      YY(1)=(VARD(L)*V(2)-VARD(L+1)*V(1))/(VARI(L+1)-VARI(L))
      YY(2)=(VARD(L+1)*V(3)-VARD(L+2)*V(2))/(VARI(L+2)-VARI(L+1))
      Y=(YY(1)*V(3)-YY(2)*V(1))/(VARI(L+2)-VARI(L))
  800 II(LI)=I
      RETURN
      END

      SUBROUTINE GEOM
C
      DIMENSION XREF(25),YREF(25),SAR(25),A(25),RSAR(25),X(25),Y(25),
     1            BOTSV(2),SA(2),VBORD(51),SPY(50,2),KFX(2),IYL(50,2),
     2            IYT(50,2)
      COMMON/SHIP/VIC,SCW
      COMMON/ALL/ BOT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(300),PN(300),
     1            PV(300),ALP(300),S(300),PSI(300),PHI(300),ZH(50)
      COMMON/ONETHRE/TWIST(2),CREF,SREF,CAVE,CLDES,STRUE,AR,ARTRUE,
     1   RTCDHT(2),CONFIG,NSSWSV(2),MSV(2),KBOT,PLAN,IPLAN,MACH
     2   ,SSWWA(50)
      COMMON/MAINONE/ICODEOF,TOTAL,AAN(2),XS(2),YS(2),KFCTS(2)
     1      ,XREG(25,2),YREG(25,2),AREG(25,2),DIH(25,2),MCD(25,2)
     2      ,XX  (25,2),YY  (25,2),AS  (25,2),TTWD(25,2),MMCD(25,2)
     3      ,AN(2),ZZ (25,2)
      REAL MACH
      CHARACTER*10 PRTCON
    1 FORMAT ( //  63X,'GEOMETRY DATA' )
    2 FORMAT (/// 45X ,A10,' REFERENCE PLANFORM HAS',I3,' CURVES',//
     1      12X,'ROOT CHORD HEIGHT =' ,F12.5 , 4X,       'VARIABLE SWEEP
     2 PIVOT POSITION',4X,'X(S) =',F12.5,5X,'Y(S) =',F12.5,//46X,
     3      'BREAK POINTS FOR THE REFERENCE PLANFORM ' / )
    3 FORMAT (8F10.4)
    4 FORMAT (8F15.5)
    5 FORMAT  (     // 47X , 'CONFIGURATION NO.' ,F8.0 /  )
    6 FORMAT(2F12.5,2E12.5,F12.5)
    7 FORMAT(       //36X,I4,44H HORSESHOE VORTICES ON LEFT HALF OF THE W
     1ING/36X,I4,10H CHORDWISE,21X,I4,9H SPANWISE//)
    8 FORMAT (22X,'POINT',6X,'X',11X,'Y',11X,'Z',10X,'SWEEP',7X,'DIHEDRA
     1L',4X,'MOVE',/ 68X,'ANGLE',8X,'ANGLE',6X,'CODE' /  )
    9 FORMAT(20X,I5,3F12.5,2F14.5, I6)
   10 FORMAT  ( / 40X, 'CURVE',I3,' IS SWEPT',F12.5,' DEGREES ON PLANFOR
     1M',I3 )
   11 FORMAT(///41X,'END OF FILE ENCOUNTERED AFTER CONFIGURATION',F7.0)
   12 FORMAT (    ///18X,'THE FIRST VARIABLE SWEEP CURVE SPECIFIED (K =',
     1         I3,' ) DOES NOT HAVE AN M CODE OF 2 FOR PLANFORM',I4)
   13 FORMAT (8F5.1,F10.4,F5.1,F10.4)
   14 FORMAT(26X,I5,2F12.5,2F16.5,4X,I4)
   15 FORMAT (     ///10X,'ERROR - PROGRAM CANNOT PROCESS PTEST =',F5.1,
     1 ' AND QTEST =',F5.1 )
   16 FORMAT  ( // 48X , 'BREAK POINTS FOR THIS CONFIGURATION' //)
   17 FORMAT (28X,'POINT',6X,'X',11X,'Y',11X,'SWEEP',10X,'DIHEDRAL',7X,
     1 'MOVE',/ 38X,'REF',9X,'REF',10X,'ANGLE',11X,'ANGLE',9X,'CODE'/ )
   18 FORMAT  (/   52X , 'SECOND PLANFORM BREAK POINTS'  / )
   19 FORMAT(////25X,34HTHE BREAKPOINT LOCATED SPANWISE AT,F11.5,3X,20HH
     1AS BEEN ADJUSTED TO,F9.5////)
   20 FORMAT  (/  47X,F5.0,' HORSESHOES IN EACH CHORDWISE ROW' )
   22 FORMAT  (/ 27X,'TABLE OF HORSESHOES IN EACH CHORDWISE ROW (FROM TI
     1P TO ROOT BEGINING WITH FIRST PLANFORM)' //,25F5.0 /,25F5.0 )
   24 FORMAT(///37X,I5,' HORSESHOES USED ON THE LEFT HALF OF THE CONFIGU
     1RATION',//  50X ,'PLANFORM        TOTAL        SPANWISE' /  )
   25 FORMAT (52X, I4 , 10X , I3 , 11X , I4 )
C
C
C        PART ONE - GEOMETRY COMPUTATION
C
C                   SECTION ONE - INPUT OF REFERENCE WING POSITION
C
C
C
      RTCDHT(1)=0
      RTCDHT(2)=0.
      YTOL      = 1.E-10
      AZY       = 1.E+13
      PIT       = 1.5707963
      RAD       = 57.29578
      IF (TOTAL.GT.0.)  GO TO 80
C
C
C     SET PLAN EQUAL TO 1. FOR A WING ALONE COMPUTAION - EVEN FOR A
C     VARIABLE SWEEP WING
C     SET PLAN EQUAL TO 2. FOR A WING - TAIL COMBINATION
C
C     SET TOTAL EQUAL TO THE NUMBER OF SETS
C       OF GROUP TWO DATA PROVIDED
C
   40 READ (28,3,END=1006) PLAN,TOTAL,CREF,SREF
      IPLAN     =PLAN
C
```

```
C
C     SET AAN(IT) EQUAL TO THE MAXIMUM NUMBER OF CURVES REQUIRED TO
C     DEFINE THE PLANFORM PERIMETER OF THE (IT) PLANFORM.
C
C     SET RTCDHT(IT) EQUAL TO THE ROOT CHORD HEIGHT OF THE LIFTING
C     SURFACE (IT),WHOSE PERIMETER POINTS ARE BEING READ IN, WITH
C     RESPECT TO THE WING ROOT CHORD HEIGHT
C
      WRITE (29,1)
      DO 58 IT = 1,IPLAN
      READ (28,3) AAN(IT),XS(IT),YS(IT),RTCDHT(IT)
      N          = AAN(IT)
      N1         = N + 1
      MAK        = 0
      IF (IPLAN.EQ.1)                      PRTCON = '           '
      IF (IPLAN.EQ.2 .AND.  IT.EQ.1 )      PRTCON = '      FIRST'
      IF (IPLAN.EQ.2 .AND.  IT.EQ.2 )      PRTCON = '     SECOND'
      WRITE (29,2) PRTCON,N,RTCDHT(IT),XS(IT),YS(IT)
      WRITE(29,17)
      DO 59 I=1,N1
      READ (28,3)  XREG(I,IT) , YREG(I,IT), DIH(I,IT), AMCD
      MCD(I,IT) = AMCD
      IF (I.EQ.1)                         GO TO 59
      IF  ( MAK.NE.0 .OR.  MCD(I-1,IT).NE.2 )     GO TO 49
      MAK   =  I-1
   49 IF  (ABS( YREG(I-1,IT)-YREG(I,IT)).LT.YTOL)  GO TO 50
      AREG(I-1,IT) = (XREG(I-1,IT)-XREG(I,IT))/(YREG(I-1,IT)-YREG(I,IT))
      ASWP = ATAN ( AREG(I-1,IT) ) * RAD
      GO TO 51
   50 YREG(I,IT) = YREG(I-1,IT)
      AREG( I-1,IT) = AZY
      ASWP         = 90.
   51 J          = I - 1
C
C     WRITE PLANFORM PERIMETER POINTS AND ANGLES
C
      WRITE(29,14)  J, XREG(J,IT),YREG(J,IT),ASWP,DIH(J,IT),MCD(J,IT)
      DIH(J,IT) =  TAN(DIH(J,IT)/RAD)
   59 CONTINUE
      KFCTS(IT) = MAK
      WRITE(29,14)  N1,XREG(N1,IT),YREG(N1,IT)
   58 CONTINUE
C
C                         PART 1 - SECTION 2
C         READ GROUP 2 DATA AND COMPUTE DESIRED WING POSITION
C
C
C    SCW MUST NOT BE SET EQUAL TO ZERO OR ONE WHEN THE WING HAS DIHEDRAL
C
C     SET SA(1),SA(2) EQUAL TO THE SWEEP ANGLE,IN DEGREES, FOR THE FIRST
C     CURVE(S) THAT CAN CHANGE SWEEP FOR EACH PLANFORM
C
C     IF A PARTICULAR VALUE OF CL IS DESIRED AT WHICH THE LOADINGS ARE
C     TO BE COMPUTED, SET CLDES EQUAL TO THIS VALUE
C     SET CLDES EQUAL TO 11. FOR A DRAG POLAR AT CL VALUES OF-.1 TO  1.0
C
```

```
C     IF PTEST IS SET EQUAL TO ONE THE PROGRAM WILL COMPUTE  CLP
C     IF QTEST IS SET EQUAL TO ONE THE PROGRAM WILL COMPUTE  CMQ AND CLQ
C     DO NOT SET BOTH PTEST AND QTEST TO ONE FOR A SINGLE CONFIGURATION
C
C     SET TWIST(1) OR TWIST(2) EQUAL TO 0. FOR A FLAT PLANFORM AND TO 1.
C     FOR A PLANFORM THAT HAS TWIST AND/OR CAMBER
C
   80 READ(28,13,END=1006)CONFIG,SCW,VIC,MACH,CLDES,
     1PTEST,QTEST,TWIST(1),SA(1),TWIST(2),SA(2)
      WRITE(29,5) CONFIG
   82 IF  ( PTEST.NE.0.  .AND.  QTEST.NE.0.  )  GO TO 1008
      IF  (SCW.EQ.0.)      GO TO 76
      DO 74 I=1,50
   74 TBLSCW(I) = SCW
      GO TO 78
   76 READ (28,3) STA
      NSTA = STA
      READ (28,3) (TBLSCW(I),TBLSCW(I+1),TBLSCW(I+2),TBLSCW(I+3)
     1                ,TBLSCW(I+4),TBLSCW(I+5),TBLSCW(I+6),TBLSCW(I+7),
     2            I = 1,NSTA,8)
   78 DO 100 IT = 1,IPLAN
      N          = AAN(IT)
      N1         =  N + 1
      DO 83 I=1,N
      XREF(I)    = XREG(I,IT)
      YREF(I)    = YREG(I,IT)
      A   (I)    = AREG(I,IT)
      RSAR(I)    = ATAN(A(I))
      IF (A(I).EQ.AZY)        RSAR(I) = PIT
   83 CONTINUE
      XREF(N1)   = XREG(N1,IT)
      YREF(N1)   = YREG(N1,IT)
      IF ( KFCTS(IT) .GT.  0 )           GO TO 79
      K      = 1
      SA(IT)   = RSAR(1) * RAD
      GO TO 77
   79 K      = KFCTS(IT)
   77 WRITE (29,10) K,SA(IT),IT
      SB          =  SA(IT)/RAD
      IF ( ABS( SB - RSAR(K) ).GT. (.1/RAD) )    GO TO 111
C     REFERENCE PLANFORM COORDINATES ARE STORED UNCHANGED FOR WINGS
C            WITHOUT CHANGE IN SWEEP
      DO 113 I=1,N
      X(I)=XREF(I)
      Y(I)=YREF(I)
      IF (RSAR(I) .EQ.  PIT )           GO TO 114
      A(I)=TAN(RSAR(I))
      GO TO 113
  114 A(I)=AZY
  113 SAR(I)=RSAR(I)
      X(N1)=XREF(N1)
      Y(N1)=YREF(N1)
      GO TO 103
C
C     CHANGES IN WING SWEEP ARE MADE HERE
C
```

```
  111 IF (MCD(K,IT).NE.2)              GO TO 1007
      KA=K-1
      DO 81 I=1,KA
      X(I)=XREF(I)
      Y(I)=YREF(I)
   81 SAR(I)=RSAR(I)
C     DETERMINE LEADING EDGE INTERSECTION BETWEEN FIXED AND VARIABLE
C            SWEEP WING SECTIONS
      SAR(K) =  SB
      A(K)   =  TAN(SB)
      SAI    =  SB-RSAR(K)
      X(K+1)=XS(IT)+(XREF(K+1)-XS(IT))*COS(SAI)+(YREF(K+1)-YS(IT))
     1      *SIN(SAI)
      Y(K+1)=YS(IT)+(YREF(K+1)-YS(IT))*COS(SAI)-(XREF(K+1)-XS(IT))
     1     *SIN(SAI)
      IF ( ABS (SB - SAR(K-1) ) .LT. (.1/RAD) )             GO TO 84
      Y(K)=X(K+1)-X(K-1)-A(K)*Y(K+1)+A(K-1)*Y(K-1)
      Y(K)=Y(K)/(A(K-1)-A(K))
      X(K)= A(K)*X(K-1)-A(K-1)*X(K+1)+A(K-1)*A(K)*(Y(K+1)-Y(K-1))
      X(K)=X(K)/(A(K)-A(K-1))
      GO TO 85
C     ELIMINATE EXTRANEOUS BREAKPOINTS
   84 X(K)=XREF(K-1)
      Y(K)=YREF(K-1)
      SAR(K)    =   SAR(K-1)
   85 K=K+1
C     SWEEP THE BREAKPOINTS ON THE VARIABLE SWEEP PANEL
C        (IT ALSO KEEPS SWEEP ANGLES IN FIRST OR FOURTH QUADRANTS)
   86 K=K+1
      SAR(K-1)=SAI+RSAR(K-1)
   99 IF ( SAR(K-1) .LE. PIT )         GO TO 102
      SAR(K-1)=SAR(K-1)-3.1415927
      GO TO  99
  102 IF ( SAR(K-1) .GE.(-PIT))        GO TO 106
      SAR(K-1)=SAR(K-1)+3.1415927
      GO TO 102
  106 IF(( SAR(K-1)).LT..0) GO TO 108
      IF  ( SAR(K-1) - PIT )           90,87,87
  108 IF  ( SAR(K-1) + PIT )           89,89,90
   87 A(K-1)=AZY
      GO TO 91
   89 A(K-1)=-AZY
      GO TO 91
   90 A(K-1)=TAN(SAR(K-1))
   91 KK        = MCD(K,IT)
      GO TO (93,92),KK
   92 Y(K)=YS(IT)+(YREF(K)-YS(IT))*COS(SAI)-(XREF(K)-XS(IT))
     1        *SIN(SAI)
      X(K)=XS(IT)+(XREF(K)-XS(IT))*COS(SAI)+(YREF(K)-YS(IT))
     1          *SIN(SAI)
      GO TO 86
C     DETERMINE THE TRAILING EDGE INTERSECTION
C        BETWEEN FIXED AND VARIABLE SWEEP WING SECTIONS
   93 IF (ABS (RSAR(K)-SAR(K-1)) .LT. (.1/RAD) )      GO TO 96
      Y(K)=XREF(K+1)-X(K-1)-A(K)*YREF(K+1)+A(K-1)*Y(K-1)
      Y(K)=Y(K)/(A(K-1)-A(K))
      X(K)=A(K)*X(K-1)-A(K-1)*XREF(K+1)+A(K-1)*A(K)*(YREF(K+1)-Y(K-1))
      X(K)=X(K)/(A(K)-A(K-1))
      GO TO 97
   96 X(K)=XREF(K+1)
      Y(K)=YREF(K+1)
   97 K=K+1
C     STORE REFERENCE PLANFORM COORDINATES ON INBOARD FIXED TRAILING
C     EDGE
      DO 98 I=K,N1
      X(I)=XREF(I)
      Y(I)=YREF(I)
   98 SAR(I-1)=RSAR(I-1)
  103 DO 101 I=1,N
      XX(I,IT)   = X(I)
      YY(I,IT)   = Y(I)
      MMCD(I,IT)= MCD(I,IT)
      TTWD(I,IT) = DIH(I,IT)
  101 AS  (I,IT) = A(I)
      XX(N1,IT)  = X(N1)
      YY(N1,IT)  = Y(N1)
      AN(IT)     = AAN(IT)
  100 CONTINUE
C
C        LINE UP BREAKPOINTS AMONG PLANFORMS
C
  299 BOTSV(1)=0
      BOTSV(2)=0.
      WRITE (29,16)
      DO 180 IT=1,IPLAN
      NIT=AN(IT)+1
      DO 178 ITT=1,IPLAN
      IF (ITT.EQ.IT)   GO TO 178
      NITT=AN(ITT)+1
      DO 176 I=1,NITT
      JPSV=0
      DO 166 JP=1,NIT
      IF(YY(JP,IT) .EQ.YY(I,ITT))    GO TO 176
  166 CONTINUE
      DO 170 JP=1,NIT
      IF (YY(JP,IT).LT.YY(I,ITT))  GO TO 168
  170 CONTINUE
      GO TO 176
  168 JPSV = JP
      IND = NIT -(JPSV -1)
      DO 172 JP=1,IND
      K2 = NIT -JP +2
      K1 = NIT -JP +1
      XX(K2,IT) = XX(K1,IT)
      YY(K2,IT) = YY(K1,IT)
      MMCD(K2,IT)= MMCD(K1,IT)
      AS(K2,IT) = AS(K1,IT)
  172 TTWD(K2,IT)=TTWD(K1,IT)
      YY(JPSV,IT)  = YY(I,ITT)
      AS(JPSV,IT)  = AS(JPSV-1,IT)
      TTWD(JPSV,IT)= TTWD(JPSV-1,IT)
      XX(JPSV,IT)  = (YY(JPSV,IT) - YY(JPSV-1,IT)) * AS(JPSV-1,IT)
```

```
     1                 +  XX(JPSV-1,IT)
      MMCD(JPSV,IT) = MMCD(JPSV-1,IT)
      AN(IT)  = AN(IT) + 1.
      NIT  = NIT + 1
  176 CONTINUE
  178 CONTINUE
C
C     SEQUENCE WING COORDINATES FROM TIP TO ROOT
C
      N1 = AN(IT)+ 1.
      DO 203 I=1,N1
  203 Q(I)     = YY(I,IT)
      DO 208 J=1,N1
      HIGH = 1.
      DO 205 I=1,N1
      IF (( Q(I)-HIGH).GE.0. )          GO TO 205
      HIGH    = Q(I)
      IH = I
  205 CONTINUE
      IF (J.NE.1) GO TO 206
      BOTSV(IT)  = HIGH
      KFX(IT)    = IH
  206 Q (IH)     = 1.
      SPY(J,IT)  = HIGH
      IF (IH.GT.KFX(IT))   GO TO 209
      IYL(J,IT) = 1
      IYT(J,IT) = 0
      GO TO 208
  209 IYL(J,IT) = 0
      IYT(J,IT) = 1
  208 CONTINUE
  180 CONTINUE
C
C     SELECT MAXIMUM B/2 AS THE WING SEMISPAN
C
      KBOT = 1
      IF (BOTSV(1).GE.BOTSV(2))  KBOT = 2
      BOT = BOTSV(KBOT)
C
C    COMPUTE NOMINAL HORSESHOE VORTEX WIDTH ALONG WING SURFACE
C
      TSPAN = 0
      ISAVE = KFX(KBOT) - 1
      I     = KFX(KBOT) - 2
  216 IF (I.EQ.0)                           GO TO 217
      IF(TTWD(I,KBOT).EQ.TTWD(ISAVE,KBOT)) GO TO 218
  217 CTWD  = COS( ATAN(TTWD(ISAVE,KBOT) ) )
      TLGTH = (YY(ISAVE+1,KBOT) - YY(I+1,KBOT) ) / CTWD
      TSPAN = TSPAN + TLGTH
      IF (I.EQ.0)                           GO TO 219
      ISAVE = I
  218 I     = I -1
      GO TO 216
  219 VI    = TSPAN / VIC
      VSTOL = VI / 2
C
```

```
C     ELIMINATE PLANFORM BREAKPOINTS WHICH ARE WITHIN (B/2)/2000 UNITS
C     LATERALLY
C
      DO 220 IT = 1,IPLAN
      N = AN(IT)
      N1= N + 1
      DO 220 J=1,N
      AA = ABS(SPY(J,IT) - SPY(J+1,IT) )
      IF ( AA.EQ.0. .OR. AA.GT.ABS(TSPAN/2000.)) GO TO 220
      IF ( AA.GT.YTOL)   WRITE(6,19) SPY(J+1,IT) , SPY(J,IT)
      DO 222 I=1,N1
      IF ( YY(I,IT).NE.SPY(J+1,IT))      GO TO 222
      YY(I,IT)  = SPY(J,IT)
  222 CONTINUE
      SPY(J+1,IT) = SPY(J,IT)
  220 CONTINUE
C
C     COMPUTE Z COORDINATES
C
      DO 236 IT=1,IPLAN
      JM  =  AN(IT) + 1.
      N1  =  AN(IT) + 1.
      DO 230  JZ=1,N1
  230 ZZ(JZ,IT) = RTCDHT(IT)
      JZ         = 1
  232 JZ         = JZ + 1
      IF  (JZ.GT.KFX(IT))     GO TO 234
      ZZ(JZ,IT) = ZZ(JZ-1,IT) +(YY(JZ,IT) - YY(JZ-1,IT) ) *TTWD(JZ-1,IT)
      GO TO 232
  234 JM         = JM-1
      IF  ( JM.EQ.KFX(IT) )   GO TO 236
      ZZ(JM,IT) = ZZ(JM+1,IT) +(YY(JM,IT)-YY(JM+1,IT)) *TTWD(JM,IT)
      GO TO 234
  236 CONTINUE
C
C     WRITE PLANFORM PERIMETER POINTS ACTUALLY USED IN THE COMPUTATIONS
C
      WRITE (29,8)
      DO 240 IT =1,IPLAN
      N    = AN(IT)
      N1   = N + 1
      IF (IT.EQ.2)  WRITE (29,18)
      DO 238 KK=1,N
      TOUT  = ATAN ( TTWD(KK,IT) )* RAD
      AOUT  = ATAN(AS(KK,IT) )*RAD
      IF (AS(KK,IT).EQ.AZY)             AOUT=90.
      WRITE (29,9)  KK,XX(KK,IT), YY(KK,IT), ZZ(KK,IT), AOUT,
     1 TOUT ,MMCD(KK,IT)
  238 CONTINUE
      WRITE (29,9) N1,XX(N1,IT),YY(N1,IT),ZZ(N1,IT)
  240 CONTINUE
C
C     PART ONE - SECTION THREE - LAY OUT YAWED HORSESHOE VORTICES
C
      STRUE = 0.
      NSSWSV(1)  =  0
      NSSWSV(2)  =  0
      MSV(1)     =  0
      MSV(2)     =  0
  700 DO 722 IT=1,IPLAN
      N1    = AN(IT) + 1.
      I     =  0
      J     = 1
      YIN   = BOTSV(IT)
      ILE   = KFX(IT)
      ITE   = KFX(IT)
C     DETERMINE SPANWISE BORDERS OF HORSESHOE VORTICES
  701 IXL   = 0
      IXT   = 0
      I     = I + 1
      IF(YIN.GE.(SPY(J,IT)+VSTOL) )     GO TO 703
C     BORDER IS WITHIN VORTEX SPACING TOLERANCE (VSTOL) OF BREAKPOINT
C     THEREFORE USE THE NEXT BREAKPOINT INBOARD FOR THE BORDER
      VBORD(I)  = YIN
      GO TO 707
C     USE NOMINAL VORTEX SPACING TO DETERMINE THE BORDER
  703 VBORD(I)  = SPY(J,IT)
C     COMPUTE SUBSCRIPTS ILE AND ITE TO INDICATE WHICH
C     BREAKPOINTS ARE ADJACENT AND WHETHER THEY ARE ON THE WING LEADING
C       EDGE OR THE TRAILING EDGE
  715 IF (J.GE.N1)                      GO TO 706
      IF (SPY(J,IT).NE.SPY(J+1,IT))     GO TO 706
      IXL        = IXL + IYL(J,IT)
      IXT        = IXT + IYT(J,IT)
      J          = J + 1
      GO TO 715
  706 YIN        = SPY(J,IT)
      IXL        = IXL  +  IYL(J,IT)
      IXT        = IXT  +  IYT(J,IT)
      J          = J + 1
  707 CPHI       = COS ( ATAN ( TTWD(ILE,IT) ) )
      IPHI = ILE - IXL
      IF ( J.GE.N1 )     IPHI = 1
      YIN  =  YIN - VI* COS ( ATAN ( TTWD(IPHI,IT) ) )
      IF  (I.NE.1)                      GO TO 709
  708 ILE        = ILE - IXL
      ITE        = ITE + IXT
      GO TO 701
C     COMPUTE COORDINATES FOR CHORDWISE ROW OF HORSESHOE VORTICES
  709 YQ         = ( VBORD(I-1) + VBORD(I) ) / 2.
      HW         = ( VBORD(I)   - VBORD(I-1))/ 2.
      IM1        = I - 1 + NSSWSV(1)
      ZH(IM1)    = ZZ(ILE,IT) + ( YQ - YY(ILE,IT) ) * TTWD(ILE,IT)
      PHI(IM1)   = TTWD(ILE,IT)
      SSWWA(IM1) = AS(ILE,IT)
      XLE       .= XX(ILE,IT) + AS(ILE,IT) * (YQ - YY(ILE,IT) )
      XTE        = XX(ITE,IT) + AS(ITE,IT) * (YQ - YY(ITE,IT) )
      XLOCAL     = ( XLE - XTE ) / TBLSCW(IM1)
C
C     COMPUTE WING AREA PROJECTED TO THE X - Y PLANE
C
```

```
      STRUE    =  STRUE + XLOCAL * TBLSCW(IM1) * (HW * 2.) * 2.
C
      NSCW       = TBLSCW(IM1)
      DO 720 JCW=1,NSCW
      AJCW       = JCW - 1
      XLEL       = XLE - AJCW * XLOCAL
      NTS    = JCW + MSV(1) + MSV(2)
      PN(NTS)    = XLEL - .25 * XLOCAL
      PV(NTS)    = XLEL - .75 * XLOCAL
      PSI(NTS)   =  ((XLE - PN(NTS))*AS(ITE,IT) + (PN(NTS) - XTE)*AS(ILE,
     1              IT) ) / (XLE - XTE) * CPHI
      S(NTS)     = HW / CPHI
      Q(NTS)     = YQ
  720 CONTINUE
      MSV(IT)    = MSV(IT) + NSCW
C
C     TEST TO DETERMINE WHEN WING ROOT (Y=0) IS REACHED
      IF  ( VBORD(I) .LT. -0.)         GO TO 708
C
      NSSWSV(IT) =  I - 1
  722 CONTINUE
      M          = MSV(1) + MSV(2)
C
C     COMPUTE ASPECT RAT10  AND  AVERAGE CHORD
C
      BOT        = - BOT
      AR         = 4.  * BOT * BOT / SREF
      ARTRUE     = 4.  * BOT * BOT / STRUE
      CAVE       = STRUE / ( 2.  * BOT )
      BETA       = ( 1.  -  MACH* MACH) ** .5
      NVTWO      = 0
      DO 354 IT=1,IPLAN
      NVONE      = 1 + (IT-1)*MSV(1)
      NVTWO      = NVTWO + MSV(IT)
      IF (TWIST(IT) .LE.  0. )         GO TO 350
      READ(28,3) (ALP(NV),ALP(NV+1),ALP(NV+2),ALP(NV+3),ALP(NV+4),ALP(NV
     1             +5),ALP(NV+6),ALP(NV+7),NV=NVONE,NVTWO,8)
      GO TO 354
  350 DO 351 NV = NVONE , NVTWO
  351 ALP(NV)    =  0.
  354 CONTINUE
      WRITE (29,24) M
      WRITE (29,25) (IT,MSV(IT),NSSWSV(IT), IT=1,IPLAN)
      IF (  SCW.NE.0.  ) WRITE (29,20) SCW
      IF (  SCW.EQ.0.  ) WRITE (29,22) (TBLSCW(I),I=1,NSTA)
C
C     APPLY PRANDTL-GLAUERT CORRECTION
C
      DO 360 NV = 1,M
      PSI(NV)    = ATAN(PSI(NV)/BETA)
      PN (NV)    = PN(NV) / BETA
  360 PV (NV)    = PV(NV) / BETA
      RETURN
 1006 ICODEOF    = 1
      WRITE(29,11)   CONFIG
      RETURN
 1007 ICODEOF   = 2
      WRITE(29,12)  K,IT
      RETURN
 1008 ICODEOF   = 3
      WRITE (29,15) PTEST,QTEST
      RETURN
      END

      SUBROUTINE GRAPH1
C
C    DEFINE IPACK ARRAY FOR LEGEND
      INTEGER*4 IPACK(35)
      INTEGER NV(100),NSSW
      REAL YQ(100),SWALE(100),SSCDRAG(100),SSCTRST(100),
     +  SSCSUCT(100),CDRAGS(100),CTHRUSS(100),CSUCTS(100)
      REAL MAX,MIN,VALMAX,VALMIN
      CHARACTER*40 L1
      COMMON /PLT1/NSSW
      DIMENSION CDRAGS1(100),YQ1(100)
C    READ ELEMENTS OF UNIT 11 INTO ARRAYS TO PLOT
       OPEN(UNIT=11,FILE='AERO1.DAT',STATUS='OLD')
       DO 25 I = 1,NSSW
         READ(11,1071)NV(I),YQ(I),SWALE(I),SSCDRAG(I),SSCTRST(I),
     +  SSCSUCT(I),CDRAGS(I),CTHRUSS(I),CSUCTS(I)
         DUM = YQ(I)
         DUMM= CDRAGS(I)
         YQ1(I)=DUM
         CDRAGS1(I)=DUMM
 1071 FORMAT  (10X ,I10, 5X, 8F12.5)
 25    CONTINUE
       CLOSE (UNIT = 11)
       CALL MAXMIN(YQ1,NSSW,VALMAX,VALMIN)
       CALL MAXMIN(CDRAGS1,NSSW,MAX,MIN)
C    DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
       L1 = 'INDUCED DRAG COEFFICENT$'
C    INITIALIZE THE GRAPHICS SYSTEM
       CALL INIT
C    LABEL X AND Y AXES USING SELF COUNTING STRINGS
       CALL XNAME('2Y/B$',100)
       CALL YNAME('INDUCED DRAG COEFFICIENT$',100)
C    DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
       CALL AREA2D(6.0,8.0)
C    DEFINE HEADING LABEL
       CALL HEADIN('INDUCED DRAG COEFF. VS. 2Y/B$',-100,1.8,1)
C    PLOT ADDITIONAL TICK MARKS
       CALL XTICKS(1)
       CALL YTICKS(1)
C    PACK LEGEND LABELS INTO ARRAY IPACK
       CALL LINES(L1,IPACK,1)
C    SET UP AXIS
       CALL GRAF(0.,.2,1.,(MIN-.005),((MAX-MIN)/5.),(MAX+.005))
C    FRAME THE SUBPLOT AREA
       CALL FRAME
       CALL MARKER(15)
       CALL THKCRV(.04)
```

```
        CALL CURVE(YQ,CDRAGS,NSSW,1)
C     CHANGE LEGEND NAME TO "CONTRIBUTION TO TOTAL COEFF."
        CALL MYLEGN('CONTRIBUTION TO TOTAL COEFF.$',100)
C     PLOT LEGEND
        CALL LEGEND(IPACK,2,1.2,7.25)
C     END PLOT
        CALL ENDPL(0)
C     CREATE GRAPHICS METAFILE P1.UIS
        CALL METAFL(1)
C     TERMINATE PLOT AT END OF PLOTTING SESSION
        CALL DONEPL
        RETURN
        END

       SUBROUTINE GRAPH2
C
C     DEFINE IPACK ARRAY FOR LEGEND
       INTEGER*4 IPACK(35)
       INTEGER NV(100),NSSW
       REAL YQ(100),SWALE(100),SSCDRAG(100),SSCTRST(100),
     +  SSCSUCT(100),CDRAGS(100),CTHRUSS(100),CSUCTS(100)
       REAL MAX,MIN,VALMAX,VALMIN
       CHARACTER*40 L1
       COMMON /PLT1/NSSW
       DIMENSION CTHRUSS1(100),YQ1(100)
C     READ ELEMENTS OF UNIT 11 INTO ARRAYS TO PLOT
        OPEN(UNIT=11,FILE='AERO1.DAT',STATUS='OLD')
        DO 25 I = 1,NSSW
          READ(11,1071)NV(I),YQ(I),SWALE(I),SSCDRAG(I),SSCTRST(I),
     +  SSCSUCT(I),CDRAGS(I),CTHRUSS(I),CSUCTS(I)
          DUM = YQ(I)
          DUMM= CTHRUSS(I)
          YQ1(I) = DUM
          CTHRUSS1(I) = DUMM
 1071 FORMAT  (10X ,I10, 5X, 8F12.5)
 25     CONTINUE
        CLOSE (UNIT = 11)
        CALL MAXMIN(YQ1,NSSW,VALMAX,VALMIN)
        CALL MAXMIN(CTHRUSS1,NSSW,MAX,MIN)
C     DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
        L1 = 'LE THRUST COEFFICENT$'
C     INITIALIZE THE GRAPHICS SYSTEM
        CALL INIT
C     LABEL X AND Y AXES USING SELF COUNTING STRINGS
        CALL XNAME('2Y/B$',100)
        CALL YNAME('LE THRUST COEFFICIENT$',100)
C     DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
        CALL AREA2D(6.0,8.0)
C     DEFINE HEADING LABEL
        CALL HEADIN('LE THRUST COEFF. VS. 2Y/B$',-100,1.8,1)
C     PLOT ADDITIONAL TICK MARKS
        CALL XTICKS(1)
        CALL YTICKS(1)
C     PACK LEGEND LABELS INTO ARRAY IPACK
        CALL LINES(L1,IPACK,1)
C     SET UP AXIS
```

```
        CALL GRAF(0.,.2,1.,(MIN-.005),((MAX-MIN)/5.),(MAX+.005))
C     FRAME THE SUBPLOT AREA
        CALL FRAME
C     PLOT PRESSURE DISTRIBUTION DATA WITH A THICK LINE AND MARKER 15
        CALL MARKER(15)
        CALL THKCRV(.04)
        CALL CURVE(YQ,CTHRUSS,NSSW,1)
C     CHANGE LEGEND NAME TO "CONTRIBUTION TO TOAL COEFF."
        CALL MYLEGN('CONTRIBUTION TO TOTAL COEFF.$',100)
C     PLOT LEGEND
        CALL LEGEND(IPACK,2,1.2,7.25)
C     END PLOT
        CALL ENDPL(0)
C     CREATE GRAPHICS METAFILE P2.UIS
        CALL METAFL(2)
C     TERMINATE PLOT AT END OF PLOTTING SESSION
        CALL DONEPL
        RETURN
        END

       SUBROUTINE GRAPH3
C
C     DEFINE IPACK ARRAY FOR LEGEND
       INTEGER*4 IPACK(35)
       INTEGER NV(100),NSSW
       REAL YQ(100),SWALE(100),SSCDRAG(100),SSCTRST(100),
     +   SSCSUCT(100),CDRAGS(100),CTHRUSS(100),CSUCTS(100)
       REAL MAX,MIN,VALMAX,VALMIN
       CHARACTER*40 L1
       COMMON /PLT1/NSSW
       DIMENSION CSUCTS1(100),YQ1(100)
C     READ ELEMENTS OF UNIT 11 INTO ARRAYS TO PLOT
        OPEN(UNIT=11,FILE='AERO1.DAT',STATUS='OLD')
        DO 25 I = 1,NSSW
          READ(11,1071)NV(I),YQ(I),SWALE(I),SSCDRAG(I),SSCTRST(I),
     +   SSCSUCT(I),CDRAGS(I),CTHRUSS(I),CSUCTS(I)
          DUM = YQ(I)
          DUMM= CSUCTS(I)
          YQ1(I)=DUM
          CSUCTS1(I)=DUMM
 1071 FORMAT  (10X ,I10, 5X, 8F12.5)
 25     CONTINUE
        CLOSE (UNIT = 11)
        CALL MAXMIN(YQ1,NSSW,VALMAX,VALMIN)
        CALL MAXMIN(CSUCTS1,NSSW,MAX,MIN)
C     DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
        L1 = 'SUCTION COEFFICENT$'
C     INITIALIZE THE GRAPHICS SYSTEM
        CALL INIT
C     LABEL X AND Y AXES USING SELF COUNTING STRINGS
        CALL XNAME('2Y/B$',100)
        CALL YNAME('SUCTION COEFFICIENT$',100)
C     DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
        CALL AREA2D(6.0,8.0)
C     DEFINE HEADING LABEL
```

```
        CALL HEADIN('SUCTION COEFF. VS. 2Y/B$',-100,1.8,1)
C     PLOT ADDITIONAL TICK MARKS
        CALL XTICKS(1)
        CALL YTICKS(1)
C     PACK LEGEND LABELS INTO ARRAY IPACK
        CALL LINES(L1,IPACK,1)
C     SET UP AXIS
        CALL GRAF(0.,.2,1.,MIN,(ABS((MAX-MIN)/5.)),(ABS(MAX+.05)))
C     FRAME THE SUBPLOT AREA
        CALL FRAME
C     PLOT PRESSURE DISTRIBUTION DATA WITH A THICK LINE AND MARKER 15
        CALL MARKER(15)
        CALL THKCRV(.04)
        CALL CURVE(YQ,CSUCTS,NSSW,1)
C     CHANGE LEGEND NAME TO "CONTRIBUTION TO TOTAL COEFF"
        CALL MYLEGN('CONTRIBUTION TO TOTAL COEFF.$',100)
C     PLOT LEGEND
        CALL LEGEND(IPACK,2,1.2,7.25)
C     END PLOT
        CALL ENDPL(0)
C     CREATE GRAPHICS METAFILE P3.UIS
        CALL METAFL(3)
C     TERMINATE PLOT AT END OF PLOTTING SESSION
        CALL DONEPL
        RETURN
        END

       SUBROUTINE GRAPH4
C
C     DEFINE IPACK ARRAY FOR LEGEND
       INTEGER*4 IPACK(35)
       INTEGER NV(100),NSSW
       REAL YQ(100),SLOAD(100),CLCL(100),CCAV(100),
     + BCLCC(100),BADLAE(100),BASLD(100),SLDT(100)
       REAL MAX,MIN,VALMAX,VALMIN
       CHARACTER*40 L1
       COMMON /PLT1/NSSW
       DIMENSION SLOAD1(100),YQ1(100)
C     READ ELEMENTS OF UNIT 12 INTO ARRAYS TO PLOT
        OPEN(UNIT=12,FILE='AERO2.DAT',STATUS='OLD')
        DO 25 I = 1,NSSW
          READ(12,15)NV(I),YQ(I),SLOAD(I),CLCL(I),CCAV(I),
     +       BCLCC(I),BADLAE(I),BASLD(I),SLOAD(I),SLDT(I)
          DUM = YQ(I)
          DUMM= SLOAD(I)
          YQ1(I)=DUM
          SLOAD1(I)=DUMM
 15     FORMAT(4X,I4,F12.5,5X,3F12.5,3X,3F12.5,3X,2F12.5)
 25     CONTINUE
        CLOSE (UNIT = 12)
        CALL MAXMIN(YQ1,NSSW,VALMAX,VALMIN)
        CALL MAXMIN(SLOAD1,NSSW,MAX,MIN)
C     DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
        L1 = 'SPAN LOAD COEFFICENT$'
C     INITIALIZE THE GRAPHICS SYSTEM
```

```
      CALL INIT
C    LABEL X AND Y AXES USING SELF COUNTING STRINGS
      CALL XNAME('2Y/B$',100)
      CALL YNAME('SPAN LOAD COEFFICIENT$',100)
C    DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
      CALL AREA2D(6.0,8.0)
C    DEFINE HEADING LABEL
      CALL HEADIN('SPAN LOAD COEFF. VS. 2Y/B$',-100,1.8,1)
C    PLOT ADDITIONAL TICK MARKS
      CALL XTICKS(1)
      CALL YTICKS(1)
C    PACK LEGEND LABELS INTO ARRAY IPACK
      CALL LINES(L1,IPACK,1)
C    SET UP AXIS
      CALL GRAF(0.,.2,1.,MIN,(ABS((MAX-MIN)/5.)),(ABS(MAX+.05)))
C    FRAME THE SUBPLOT AREA
      CALL FRAME
C    PLOT PRESSURE DISTRIBUTION DATA WITH A THICK LINE AND MARKER 15
      CALL MARKER(15)
      CALL THKCRV(.04)
      CALL CURVE(YQ,SLOAD,NSSW,1)
C    CHANGE LEGEND NAME TO "COEFFICIENT OF LIFT(WING) = 1.0"
      CALL MYLEGN('COEFFICIENT OF LIFT(WING) = 1.0$',100)
C    PLOT LEGEND
      CALL LEGEND(IPACK,2,1.2,7.25)
C    END PLOT
      CALL ENDPL(0)
C    CREATE GRAPHICS METAFILE P4.UIS
      CALL METAFL(4)
C    TERMINATE PLOT AT END OF PLOTTING SESSION
      CALL DONEPL
      RETURN
      END

     SUBROUTINE GRAPH5
C
C    DEFINE IPACK ARRAY FOR LEGEND
     INTEGER*4 IPACK(35)
     INTEGER NV(100),NSSW
     REAL YQ(100),SLOAD(100),CLCL(100),CCAV(100),
    + BCLCC(100),BADLAE(100),BASLD(100),SLDT(100)
     REAL MAX,MIN,VALMAX,VALMIN
     CHARACTER*40 L1
     COMMON /PLT1/NSSW
     DIMENSION CLCL1(100),YQ1(100)
C    READ ELEMENTS OF UNIT 12 INTO ARRAYS TO PLOT
      OPEN(UNIT=12,FILE='AERO2.DAT',STATUS='OLD')
      DO 25 I = 1,NSSW
        READ(12,15)NV(I),YQ(I),SLOAD(I),CLCL(I),CCAV(I),
    +      BCLCC(I),BADLAE(I),BASLD(I),SLOAD(I),SLDT(I)
        DUM = YQ(I)
        DUMM= CLCL(I)
        YQ1(I)=DUM
        CLCL1(I)=DUMM
 15   FORMAT(4X,I4,F12.5,5X,3F12.5,3X,3F12.5,3X,2F12.5)
 25   CONTINUE
```

```
        CLOSE (UNIT = 12)
        CALL MAXMIN(YQ1,NSSW,VALMAX,VALMIN)
        CALL MAXMIN(CLCL1,NSSW,MAX,MIN)
C     DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
        L1 = ' COEFFICENT OF LIFT RATIO$'
C     INITIALIZE THE GRAPHICS SYSTEM
        CALL INIT
C     LABEL X AND Y AXES USING SELF COUNTING STRINGS
        CALL XNAME('2Y/B$',100)
        CALL YNAME('COEFFICIENT OF LIFT RATIO (SECTION/WING)$',100)
C     DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
        CALL AREA2D(6.0,8.0)
C     DEFINE HEADING LABEL
        CALL HEADIN('COEFF. OF LIFT RATIO VS. 2Y/B$',-100,1.8,1)
C     PLOT ADDITIONAL TICK MARKS
        CALL XTICKS(1)
        CALL YTICKS(1)
C     PACK LEGEND LABELS INTO ARRAY IPACK
        CALL LINES(L1,IPACK,1)
C     SET UP AXIS
        CALL GRAF(0.,.2,1.,MIN,(ABS((MAX-MIN)/5.)),(ABS(MAX+.05)))
C     FRAME THE SUBPLOT AREA
        CALL FRAME
C     PLOT PRESSURE DISTRIBUTION DATA WITH A THICK LINE AND MARKER 15
        CALL MARKER(15)
        CALL THKCRV(.04)
        CALL CURVE(YQ,CLCL,NSSW,1)
C     CHANGE LEGEND NAME TO "COEFFICIENT OF LIFT(WING) = 1.0"
        CALL MYLEGN('COEFFICIENT OF LIFT(WING) = 1.0$',100)
C     PLOT LEGEND
        CALL LEGEND(IPACK,2,1.2,7.25)
C     END PLOT
        CALL ENDPL(0)
C     CREATE GRAPHICS METAFILE P5.UIS
        CALL METAFL(5)
C     TERMINATE PLOT AT END OF PLOTTING SESSION
        CALL DONEPL
        RETURN
        END

       SUBROUTINE GRAPH6(NUMVOR)
C
C     DEFINE IPACK ARRAY FOR LEGEND
       INTEGER*4 IPACK(35)
       INTEGER NUMVOR,METH,MORT,INC,MANY,COUNT
       REAL PNPRS(120),PVPRS(120),QS(120),CPS(120)
       REAL MAX,MIN,VALMAX,VALMIN
       CHARACTER*40 L1
       COMMON/SHIP/VIC,SCW
       DIMENSION CPS1(120),PNPRS1(120)
       MANY = INT(SCW)
  603 FORMAT(1X,2I3,4F12.5)
C     READ ELEMENTS OF UNIT 13 INTO ARRAYS TO PLOT
        OPEN(UNIT=13,FILE='AERO3.DAT',STATUS='OLD')
        INC = 1
        COUNT = 0
```

```
 14    READ(13,603) METH,MORT,PNPR,PVPR,Q,CP
       IF (METH .EQ. NUMVOR) THEN
         PNPRS(INC) = PNPR
         PVPRS(INC) = PVPR
         QS(INC)     = Q
         CPS(INC)    = CP
         INC = INC + 1
         COUNT = COUNT + 1
         GO TO 14
       ELSEIF(METH.EQ.99) THEN
         GO TO 15
       ELSE
         GO TO 14
       ENDIF
 15    PRINT *, ' '
       CLOSE (UNIT = 13)
       DO I = 1,COUNT
         DUM=CPS(I)
         DUMM=PNPRS(I)
         CPS1(I)=DUM
         PNPRS1(I)=DUMM
       END DO
C***********************************************************
       CALL MAXMIN(PNPRS1,COUNT,VALMAX,VALMIN)
       CALL MAXMIN(CPS1,COUNT,MAX,MIN)
C    DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
       L1 = ' DELTA CP VS. X C/4 $'
C    INITIALIZE THE GRAPHICS SYSTEM
       CALL INIT
C    LABEL X AND Y AXES USING SELF COUNTING STRINGS
       CALL XNAME('X C/4$',100)
       CALL YNAME('COEFFICIENT OF PRESSURE CHANGE$',100)
C    DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
       CALL AREA2D(6.0,8.0)
C    DEFINE HEADING LABEL
       CALL HEADIN('DELTA CP VS. X C/4$',-100,1.8,1)
C    PLOT ADDITIONAL TICK MARKS
       CALL XTICKS(1)
       CALL YTICKS(1)
C    PACK LEGEND LABELS INTO ARRAY IPACK
       CALL LINES(L1,IPACK,1)
C    SET UP AXIS
       CALL GRAF((VALMIN-.05),((VALMAX-VALMIN)/2.5),(VALMAX+.05),
     +     (MIN-.1),((MAX-MIN)/5.),(MAX+.1))
C    FRAME THE SUBPLOT AREA
       CALL FRAME
C    PLOT PRESSURE DISTRIBUTION DATA WITH A THICK LINE AND MARKER 15
       CALL MARKER(15)
       CALL THKCRV(.04)
       CALL CURVE(PNPRS,CPS,COUNT,1)
C    PLOT MESSAGE
       CALL MESSAG('HORSESHOE VORTEX -- NUMBER $',100,1.,8.25)
       CALL INTNO(NUMVOR,'ABUT','ABUT')
C    CHANGE LEGEND NAME TO "COEFFICIENT OF LIFT(WING) = 1.0"
       CALL MYLEGN('COEFFICIENT OF LIFT(WING) = 1.0$',100)
C    PLOT LEGEND
```

```
        CALL LEGEND(IPACK,2,1.2,7.25)
C     END PLOT
        CALL ENDPL(0)
C     CREATE GRAPHICS METAFILE P6.UIS
        CALL METAFL(6)
C     TERMINATE PLOT AT END OF PLOTTING SESSION
        CALL DONEPL
        RETURN
        END

      SUBROUTINE INFSUB (BOT,FUI,FVI,FWI)
C
      COMMON/INSUB23/PSII,APHII,XXX,YYY,ZZZ,SNN,TOLRNC
      FC =COS(PSII)
      FS =SIN(PSII)
      FT =FS/FC
      FPC=COS(APHII)
      FPS=SIN(APHII)
      FPT=FPS/FPC
      F1 =XXX+SNN*FT*FPC
      F2 =YYY+SNN*FPC
      F3 =ZZZ+SNN*FPS
      F4 =XXX-SNN*FT*FPC
      F5 =YYY-SNN*FPC
      F6 =ZZZ-SNN*FPS
      FFA=    (XXX**2+(YYY*FPS)**2+FPC**2*((YYY*FT)**2+(ZZZ/FC)**2-2.*
     1XXX*YYY*FT)-2.*ZZZ*FPC*(YYY*FPS+XXX*FT*FPS))
      FFB=(F1*F1+F2*F2+F3*F3)**.5
      FFC=(F4*F4+F5*F5+F6*F6)**.5
      FFD=F5*F5+F6*F6
      FFE=F2*F2+F3*F3
      FFF=(F1*FPC*FT+F2*FPC+F3*FPS)/FFB  -  (F4*FPC*FT+F5*FPC+F6*FPS)/
     1FFC
C
C     THE TOLERANCE SET AT THIS POINT IN THE PROGRAM MAY NEED TO BE
C     CHANGED FOR COMPUTERS OTHER THAN THE CDC 6000 SERIES
C
C
      IF(ABS(FFA).LT.(BOT*15.E-5)**2)  GO TO 262
      FUONE=(ZZZ*FPC-YYY*FPS)*FFF/FFA
      FVONE=(XXX*FPS-ZZZ*FT*FPC)*FFF/FFA
      FWONE=(YYY*FT-XXX)*FFF/FFA*FPC
      GO TO 265
  262 FUONE=0
      FVONE=0
      FWONE=0.
  265 IF(ABS(FFD).LT.TOLRNC) GO TO 263
C
      FVTWO= F6*(1.-F4/FFC)/FFD
      FWTWO=-F5*(1.-F4/FFC)/FFD
      GO TO 266
  263 FVTWO=0
      FWTWO=0.
  266 IF(ABS(FFE).LT.TOLRNC) GO TO 264
C
      FVTHRE=-F3*(1.-F1/FFB)/FFE
      FWTHRE=F2*(1.-F1/FFB)/FFE
C
      GO TO 267
  264 FVTHRE=0
      FWTHRE=0.
  267 FUI=FUONE
      FVI=FVONE+FVTWO+FVTHRE
      FWI=FWONE+FWTWO+FWTHRE
      RETURN
      END

      SUBROUTINE MATX
C
      DIMENSION YY(2),FU(2),FV(2),FW(2),FVN(300,300),IPIVOT(300),
     1          INDEX(300,2)
      COMMON/ALL/ BOT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(300),PN(300),
     1            PV(300),ALP(300),S(300),PSI(300),PHI(300),ZH(50)
      COMMON/TOTHRE/ CIR(300,2),SECTRST(50)
      COMMON/INSUB23/APSI,APHI ,XX ,YYY,ZZ ,SNN,TOLC
C
C
C
C     PART 2 - COMPUTE CIRCULATION TERMS
C
C
C
      FPI    =  12.5663704
      IM     =    2
      NMAX   =  300
C
C
C     THE TOLERANCE SET AT THIS POINT IN THE PROGRAM MAY NEED TO BE
C     CHANGED FOR COMPUTERS OTHER THAN THE CDC 6000 SERIES
C
C
      TOLC=(BOT*15.E-05)**2
      DO 6667 NUU=1,NMAX
      DO 6667 NUT=1,NMAX
      FVN(NUU,NUT)=0.
 6667 CONTINUE
      DO 308 NV=1,M
      CIR(NV,1)= 12.5663704 * ALP(NV)
      CIR(NV,2)= 12.5663704
      IF (PTEST.NE.0.)   CIR(NV,2) = -1.0964155 * Q(NV) / BOT
      IF (QTEST.NE.0. )  CIR(NV,2) = -1.0964155 * PV(NV) *BETA
  308 CONTINUE
      IZZ=1
      NNV=TBLSCW(IZZ)
      DO 314 NV=1,M
      IZ=1
      NNN=TBLSCW(IZ)
      DO 316 NN=1,M
      APHI    = ATAN(PHI(IZ))
      APSI    = PSI(NN)
      XX=PV(NV)-PN(NN)
      YY(1)=Q(NV)-Q(NN)
      YY(2)=Q(NV)+Q(NN)
      ZZ=ZH(IZZ)-ZH(IZ)
      SNN       = S(NN)
      DO 261 I=1,2
      YYY       = YY(I)
      CALL INFSUB (BOT,FU(I),FV(I),FW(I))
      APHI=-APHI
      APSI=-APSI
  261 CONTINUE
      IF(PTEST.NE.0.) GO TO 342
      FVN(NV,NN)=FW(1)-FV(1)*PHI(IZ)+FW(2)-FV(2)*PHI(IZ)
      GO TO 312
  342 FVN(NV,NN)=FW(1)-FV(1)*PHI(IZ)-FW(2)+FV(2)*PHI(IZ)
  312 IF (NN.LT.NNN .OR. NN.EQ.M ) GO TO 316
      IZ=IZ+1
      NNN=NNN+TBLSCW(IZ)
  316 CONTINUE
      IF (NV.LT.NNV .OR. NV.EQ.M ) GO TO 314
      IZZ=IZZ+1
      NNV=NNV+TBLSCW(IZZ)
  314 CONTINUE
      CALL AMATINV(FVN,M,CIR,IM,DETERM,IPIVOT,INDEX,NMAX,ISCALE)
      IZZA  =  IZZ
      DO 320  NZ=1,IZZA
  320 SECTRST(NZ) = 0.
      IZZ=1
      NNV=TBLSCW(IZZ)
      DO 614 NV=1,M
      IZ=1
      NNN=TBLSCW(IZ)
      VELIN  =  0.
      DO 616 NN=1,M
      APHI     = ATAN(PHI(IZ))
      APSI     = PSI(NN)
      XX=PN(NV)-PN(NN)
      YY(1) = Q(NV) - Q(NN)
      YY(2) = Q(NV) + Q(NN)
      ZZ=ZH(IZZ)-ZH(IZ)
      SNN       = S(NN)
      DO 661 I=1,2
      YYY       = YY(I)
      CALL INFSUB (BOT,FU(I),FV(I),FW(I))
      APHI=-APHI
      APSI=-APSI
  661 CONTINUE
      VELIN  =  ((FW(1)+FW(2)) - (FV(1)+FV(2)) * TAN(APHI) )*CIR(NN,2)
     1       /FPI + VELIN
      IF (NN.LT.NNN .OR. NN.EQ.M ) GO TO 616
      IZ=IZ+1
      NNN=NNN+TBLSCW(IZ)
  616 CONTINUE
      CTCP     = - (VELIN - 1. ) *2. * CIR(NV,2)
      SECTRST(IZZ) = SECTRST(IZZ) + CTCP
      IF (NV.LT.NNV .OR. NV.EQ.M ) GO TO 614
      IZZ=IZZ+1
      NNV=NNV+TBLSCW(IZZ)
  614 CONTINUE
      RETURN
      END

      SUBROUTINE QUERY(NANS)
C
C  ROUTINE TO TRAP ERRORS CAUSED BY IMPROPER RESPONSES TO QUESTIONS.
C  THE COMPUTER GENERATES AND ERROR WHEN A CHARACTER IS SUPPLIED TO
C  A QUESTION EXPECTING AN INTEGER OR REAL VALUE.
C
      NQTEST=0
    1 CONTINUE
      IF (NQTEST .GT. 0) THEN
         PRINT *, '  CHARACTER VALUES ARE NOT VALID.'
         PRINT *, '  PLEASE ENTER AN INTEGER VALUE.'
      END IF
      NQTEST = NQTEST + 1
      READ (5,*,ERR=1)NANS
      RETURN
      END
```

APPENDIX J. PROGRAM SUPER COMPUTER CODE

```
      PROGRAM SUPER
C
C *** MODIFIED FOR USE ON THE MICROVAX/2000 BY R. MARGASON.
C *** MODIFIED FOR GRAPHICAL OUTPUT AND/OR PRINTING OPTIONS BY C.M.
C     MACALLISTER (AUG 89). FINAL UPDATES MADE, NOV 89 - (CMM).
C
C     THE SUPER PROGRAM HAS BEEN ADAPTED FROM A NATIONAL AERONAUTICS
C     AND SPACE ADMINISTRATION (NASA) FORTRAN PROGRAM AND HAS BEEN
C     USED CONSIDERABLY AT THE LANGLEY RESEARCH CENTER AND IN INDUSTRY.
C     THE PURPOSE OF THE SUPER PROGRAM IS TO ESTIMATE THE SUPERSONIC
C     AERODYNAMIC CHARACTERISTICS OF COMPLEX PLANFORMS.  LINEARIZED
C     SUPERSONIC LIFTING SURFACE THEORY IS EMPLOYED TO CALCULATE THE
C     AERODYNAMIC CHARACTERISTICS OF A WARPED WING OF AN ARBITRARY
C     PLANFORM.  THE USE OF THIS PROGRAM IS CONFINED TO THE SUPERSONIC
C     FLOW REGIME.  IN ADDITION, THE LINEARIZED SUPERSONIC LIFTING
C     SURFACE THEORY APPLIES TO WINGS HAVING NEGLIBLE THICKNESS AND
C     ESSENTIALLY PLANAR CAMBER SURFACES.
C
      DIMENSION DUMB(6891)
      INTEGER GRAPHOPT,OUTER,LSTA,NSTA
      REAL SPAFRACT,CHOFRACT
      CHARACTER*1 PRINT,GRAPH,COPY,PLOT1,PLOT2,PLOT3
      CHARACTER*1 PLOT4,PLOT5
      CHARACTER*20 CASEFN, OUTFIL
      COMMON TYB2(51),TZORD(26,51),JBYMAX,NON,NOPCT,RATIO,XLEO,XTEO,
     1TPCT(26),TXLE(50),TXTE(50),DZDX,XMAX,CBAR,TDZDX(105,51),XM,NOM,
     2TMACH(5),TZSKAL,REFAR,SPAN,XO,PI,CNPOD,CAPOD,TCNPOD(5),TCAPOD(5)
      COMMON FDZDX,XLEOF,TXLEF(50),NFLAP2,NFLAP1,XMREF
      COMMON TYPEX,NLEX,NTEX,TBLEX(15),TBLEY(15),TBTEX(15),TBTEY(15)
      COMMON IDENT(8)
      COMMON /SPAN/SPAFRACT
      COMMON /CHORD/CHOFRACT
      COMMON /PLOT1/LSTA
      COMMON /HEALEY/RCL9,RCL9F
      EQUIVALENCE (DUMB(1),TYB2(1))
      NAMELIST/INPT1/TYB2,TZORD,JBYMAX,NON,NOPCT,XLEO,XTEO,TPCT,
     1TXLE,TXTE,XMAX,CBAR,XM,NOM,TMACH,TZSKAL,REFAR,SPAN,XO,CNPOD,CAPOD,
     1TCNPOD,TCAPOD,FDZDX,XLEOF,TXLEF,NFLAP2,NFLAP1,
     1TYPEX,NTEX,NLEX,TBLEX,TBLEY,TBTEX,TBTEY,XMREF
  100 FORMAT  (A20)
  101 FORMAT (/// '    START OF A NEW CASE, CASE FILE NAME IS ', A20//)
  102 FORMAT (    '    THE OUTPUT FILE NAME IS "OUTFILE.DAT" ',//)
C
C       CREATE FILES WHICH WILL BE USED TO PLOT THE RESULTS
C
C   OPEN FILE FOR SPANWISE PRESSURE DISTRIBUTION OUTPUT
      OPEN (UNIT=11,
     2      FILE= 'SPWPD.DAT',
     2      ORGANIZATION= 'SEQUENTIAL',
     2      ACCESS= 'SEQUENTIAL',
     2      RECORDTYPE= 'VARIABLE',
     2      FORM= 'FORMATTED',
     2       STATUS= 'UNKNOWN')
C
C   OPEN FILE FOR DRAG POLAR OUTPUT
      OPEN (UNIT=12,
     2       FILE= 'DRAGPO.DAT',
     2       ORGANIZATION= 'SEQUENTIAL',
     2       ACCESS= 'SEQUENTIAL',
     2       RECORDTYPE= 'VARIABLE',
     2       FORM= 'FORMATTED',
     2       STATUS= 'UNKNOWN')
C   OPEN FILE FOR STREAMWISE LIFT DISTRIBUTION OUTPUT
      OPEN (UNIT=13,
     2       FILE= 'SWLD.DAT',
     2       ORGANIZATION= 'SEQUENTIAL',
     2       ACCESS= 'SEQUENTIAL',
     2       RECORDTYPE= 'VARIABLE',
     2       FORM= 'FORMATTED',
     2       STATUS= 'UNKNOWN')
C
C   OPEN FILE FOR SPANWISE LIFT DISTRIBUTION OUTPUT
      OPEN (UNIT=14,
     2       FILE= 'SPWLD.DAT',
     2       ORGANIZATION= 'SEQUENTIAL',
     2       ACCESS= 'SEQUENTIAL',
     2       RECORDTYPE= 'VARIABLE',
     2       FORM= 'FORMATTED',
     2       STATUS= 'UNKNOWN')
C   OPEN FILE FOR CHORDWISE PRESSURE DISTRIBUTION OUTPUT
      OPEN (UNIT=15,
     2       FILE= 'CWPD.DAT',
     2       ORGANIZATION= 'SEQUENTIAL',
     2       ACCESS= 'SEQUENTIAL',
     2       RECORDTYPE= 'VARIABLE',
     2       FORM= 'FORMATTED',
     2       STATUS= 'UNKNOWN')
C
C       INPUT THE FILE NAME OF THE CASE TO BE RUN
C
      PRINT *
      WRITE (*,*)' PROGRAM SUPER - SUPERSONIC VORTEX LATTICE ANALYSIS'
      PRINT *
    2 WRITE (*,*)  '            ENTER THE INPUT FILE NAME '
      WRITE (*,*)'       USE  LAST.END  AS THE DATA FILE NAME '
      WRITE (*,*)'                  TO STOP THE PROGRAM'
      PRINT *
      READ (*,100)  CASEFN
      IF  ( CASEFN.EQ.'LAST.END' )  GO TO 99
      IF  ( CASEFN.EQ.'last.end' )  GO TO 99
      OPEN ( 25, FILE=CASEFN, STATUS='OLD' )
C
      OPEN (26, FILE ='OUTER.DAT', STATUS = 'NEW' )
      OPEN (62, FILE ='OUTFILE.DAT', STATUS = 'NEW' )
      WRITE (26,*) ' PROGRAM SUPER, SUPERSONIC VORTEX LATTICE ANALYSIS'
      WRITE (26,101)  CASEFN
      WRITE (26,102)
      WRITE (62,*) ' PROGRAM SUPER, SUPERSONIC VORTEX LATTICE ANALYSIS'
      WRITE (62,101)  CASEFN
      WRITE (62,102)
      READ (25,3,END=99) IDENT
    3 FORMAT (8A10)
      XMREF=0.0
      DO 4 KAK=1,6891
C
    4 DUMB(KAK)=0.0
      FDZDX=0.0
      PI=3.1415926
      RATIO=1.
      TYPEX = 0.0
      TZSKAL=0
      CNPOD=0.0
      CAPOD=0.0
      TSEC1 = SECNDS(0.0)
      READ (25,INPT1)
      WRITE (26,201)
      WRITE (62,201)
C     PRINT 201
  201 FORMAT(1H1//31X,60H*****LINEARIZED THEORY SUPERSONIC WING ANALYSIS
     $ PROGRAM*****/46X,28HLANGLEY PROGRAM NUMBER A4410)
    1 WRITE (26,200) IDENT
      WRITE (62,200) IDENT
  200 FORMAT (///1X,8A10///)
      WRITE(26,7)
      WRITE(62,7)
    7 FORMAT(2X///39X,41H***COMPLETE INPUT DATA,NAMELIST FORMAT***)
      WRITE(26,INPT1)
      WRITE(62,INPT1)
      CALL P916AF
      TIME = SECNDS(TSEC1)
C      PRINT 8,TIME
      WRITE(26,8)TIME
      WRITE(62,8)TIME
    8 FORMAT(2X///15X,29HCENTRAL PROCESSING UNIT TIME=F12.3,5H SEC.)
      WRITE (26,202)
      WRITE (62,202)
C     PRINT 202
  202 FORMAT (1H1)
      CLOSE (UNIT = 25)
      CLOSE (UNIT = 26)
      CLOSE (UNIT = 62)
      PRINT *
      PRINT *, '  PROGRAM RESULTS HAVE BEEN WRITTEN TO THE FILE'
      PRINT *, '                  OUTFILE.DAT.'
      PRINT *, 'WOULD YOU LIKE A PRINTED COPY OF THIS OUTPUT FILE?'
      PRINT *, '               YES OR NO (Y/N)'
      PRINT *
      READ 1002, PRINT
 1002 FORMAT(A1)
      IF (PRINT.EQ.'Y'.OR.PRINT.EQ.'y')THEN
        CALL LIB$SPAWN('PRINT OUTFILE.DAT')
      ENDIF
      PRINT *
      PRINT *, 'WOULD YOU LIKE THE OUTPUT FILE COPIED TO ANOTHER'
      PRINT *, '      FILE FOR FUTURE REFERENCE (Y/N) ? '
      PRINT *
      READ 1002,COPY
      IF (COPY .EQ. 'Y'.OR.COPY.EQ.'y') THEN
        PRINT *, 'WHAT NAME WOULD YOU LIKE FOR THE OUTPUT FILE?'
        PRINT *, '                 1)  TOMCAT.DAT'
        PRINT *, '                 2)  PHANTOM.DAT'
        PRINT *, '                 3)  INTRUDER.DAT'
        PRINT *, '                 4)  CRUSADOR.DAT'
        PRINT *, ' '
        PRINT *, 'ENTER 1,2,3 OR 4'
 69     READ 1006, OUTER
      IF (OUTER .LT. 1 .OR. OUTER .GT. 4) THEN
         PRINT *, 'INVALID ENTRY, ENTER INTEGER BETWEEN'
         PRINT *, 'ONE(1) AND FOUR(4).'
         PRINT *, ' '
         GO TO 69
      ENDIF
        IF (OUTER.EQ.1) CALL LIB$SPAWN('COPY OUTFILE.DAT TOMCAT.DAT')
        IF (OUTER.EQ.2) CALL LIB$SPAWN('COPY OUTFILE.DAT PHANTOM.DAT')
        IF (OUTER.EQ.3) CALL LIB$SPAWN('COPY OUTFILE.DAT INTRUDER.DAT')
        IF (OUTER.EQ.4) CALL LIB$SPAWN('COPY OUTFILE.DAT CRUSADER.DAT')
      ENDIF
      PRINT *,'WOULD YOU LIKE TO GRAPH THE RESULTS (Y/N)?'
      PRINT *
      READ 1002,GRAPH
      IF (GRAPH .EQ.'Y'.OR.GRAPH.EQ.'y')THEN
      PRINT *, ' '
      PRINT *, ' '
 41   PRINT *, 'WHICH OF THE FOLLOWING RELATIONSHIPS'
      PRINT *, '      DO YOU WANT PLOTTED?'
      PRINT *
      PRINT *, '   1) SPANWISE PRESSURE DISTRIBUTION'
      PRINT *, '   2) CHORDWISE PRESSURE DISTRIBUTION'
      PRINT *, '   3) DRAG POLAR (CL VS. CD)'
      PRINT *, '   4) STREAMWISE LIFT DISTRIBUTION'
      PRINT *, '   5) SPANWISE LIFT DISTRIBUTION'
      PRINT *, '   6) NONE'
      PRINT *
      PRINT *, 'INPUT OPTION NO. (1,2,3,4,5 OR 6)'
 42   READ 1006, GRAPHOPT
      IF (GRAPHOPT .LT. 1 .OR. GRAPHOPT .GT. 6) THEN
         PRINT *, 'INVALID ENTRY, ENTER INTEGER BETWEEN'
         PRINT *, 'ONE(1) AND SIX(6).'
         PRINT *, ' '
         GO TO 42
      ENDIF
C ***************
      IF (GRAPHOPT .EQ. 1) THEN
       PRINT *, ' AT WHAT CHORDAL FRACTION(X/L) WOULD YOU LIKE TO'
       PRINT *, '    SEE THE SPANWISE PRESSURE DISTRIBUTION?'
       PRINT *, '       ENTER DECIMAL FRACTION (E.G. .25)'
 67    READ 1008, CHOFRACT
1008   FORMAT(F8.6)
       IF (CHOFRACT .LT. 0. .OR. CHOFRACT .GT.1.) THEN
         PRINT *, ' '
```

```
          PRINT *, 'INVALID ENTRY. TRY AGAIN|'
          PRINT *, 'PLEASE ENTER DECIMAL NUMERAL (E.G. .25)'
          GO TO 67
        ENDIF
        LSTA = INT(CHOFRACT/.023333333)
        CALL GRAPH1(LSTA)
C     GET A HARDCOPY OF THIS GRAPHIC
        CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
     +SIZE=A P1.UIS')
       CALL LIB$SPAWN('CONTINUE')
       PRINT *, ' '
       PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
       PRINT *, ' '
       READ 1002, PLOT1
       IF (PLOT1.EQ.'Y'.OR.PLOT1.EQ.'y')THEN
         CALL LIB$SPAWN('PRINT P1.REN')
       ENDIF
       GO TO 41
       ENDIF
C *************
       IF (GRAPHOPT .EQ. 2) THEN
        PRINT *, ' '
        PRINT *, ' AT WHAT HALF SPAN FRACTION(Y/B/2) WOULD YOU LIKE TO'
        PRINT *, '       SEE THE CHORDAL PRESSURE DISTRIBUTION?'
        PRINT *, '          ENTER DECIMAL FRACTION (E.G. .25)'
  68    READ 1008, SPAFRACT
        IF (SPAFRACT .LT. 0. .OR. SPAFRACT .GT.1.) THEN
          PRINT *, ' '
          PRINT *, 'INVALID ENTRY. TRY AGAIN|'
          PRINT *, 'PLEASE ENTER DECIMAL NUMERAL (E.G. .25)'
          GO TO 68
        ENDIF
        NSTA = INT(SPAFRACT/.033333333)
        CALL GRAPH2(NSTA)
C     GET A HARDCOPY OF THIS GRAPHIC
        CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
     +SIZE=A P2.UIS')
       CALL LIB$SPAWN('CONTINUE')
       PRINT *, ' '
       PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
       PRINT *, ' '
       READ 1002, PLOT2
       IF (PLOT2.EQ.'Y'.OR.PLOT2.EQ.'y')THEN
         CALL LIB$SPAWN('PRINT P2.REN')
       ENDIF
       GO TO 41
       ENDIF
C *************
       IF (GRAPHOPT .EQ. 3) THEN
        CALL GRAPH3
C     GET A HARDCOPY OF THIS GRAPHIC
        CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
     +SIZE=A P3.UIS')
       CALL LIB$SPAWN('CONTINUE')
       PRINT *, ' '
       PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
```

```
      PRINT *, ' '
      READ 1002, PLOT3
      IF (PLOT3.EQ.'Y'.OR.PLOT3.EQ.'y')THEN
        CALL LIB$SPAWN('PRINT P3.REN')
      ENDIF
      GO TO 41
      ENDIF
C *************
      IF (GRAPHOPT .EQ. 4) THEN
       CALL GRAPH4
C     GET A HARDCOPY OF THIS GRAPHIC
       CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
     +SIZE=A P4.UIS')
      CALL LIB$SPAWN('CONTINUE')
      PRINT *, ' '
      PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
      PRINT *, ' '
      READ 1002, PLOT4
      IF (PLOT4.EQ.'Y'.OR.PLOT4.EQ.'y')THEN
        CALL LIB$SPAWN('PRINT P4.REN')
      ENDIF
      GO TO 41
      ENDIF
C *************
      IF (GRAPHOPT .EQ. 5) THEN
       CALL GRAPH5
C     GET A HARDCOPY OF THIS GRAPHIC
       CALL LIB$SPAWN('RENDER/DEVICE=LA210/DRAFT_QUALITY/PAPER_
     +SIZE=A P5.UIS')
      CALL LIB$SPAWN('CONTINUE')
      PRINT *, ' '
      PRINT *, 'WOULD YOU LIKE A PRINT OF THIS PLOT? (Y/N)'
      PRINT *, ' '
      READ 1002, PLOT5
      IF (PLOT5.EQ.'Y'.OR.PLOT5.EQ.'y')THEN
        CALL LIB$SPAWN('PRINT P5.REN')
      ENDIF
      GO TO 41
      ENDIF
C *************
      IF (GRAPHOPT .EQ. 6) THEN
        GO TO 192
      ENDIF
      ENDIF
 1006 FORMAT(I1)
C ************* OPTION TO MAKE ANOTHER RUN ***************
 192  PRINT *
      PRINT *, 'DO YOU WISH TO :   '
      PRINT *, '      1) MAKE ANOTHER RUN OR'
      PRINT *. '      2) END THIS SESSION'
      PRINT *, '   ENTER 1 OR 2.'
      PRINT *
      CALL QUERY (NANS)
      CALL CLRSCRN
      CLOSE (UNIT = 11)
      CLOSE (UNIT = 12)
      CLOSE (UNIT = 13)
      CLOSE (UNIT = 14)
      CLOSE (UNIT = 15)
      CLOSE (UNIT = 38)
      IF (NANS .EQ. 1) GO TO 2
   99 STOP
      END

      SUBROUTINE CLRSCRN
C
C  LIBRARY ROUTINE TO CLEAR THE SCREEN.
C
      ISTAT = LIB$ERASE_PAGE (1,1)
      RETURN
      END

      SUBROUTINE GRAPH1(LSTA)
C
C    DEFINE IPACK ARRAY FOR LEGEND
      INTEGER*4 IPACK(35)
      INTEGER LSTA,COUNT,INC
      REAL LSOP(100),JBYS(100),YBO2(100),XPRINT(100),TBCPF(100),
     +    TBCP(100)
      REAL MAX,MIN,VALMAX,VALMIN,MAXY,MINY,CHOFRACT
      CHARACTER*40 L1,L2
      COMMON /CHORD/CHOFRACT
      DIMENSION YARRY(100),CP1ARRY(100),CP2ARRY(100)
C    READ ELEMENTS OF UNIT 11 INTO ARRAYS TO PLOT
       OPEN(UNIT=11,FILE='SPWPD.DAT',STATUS='OLD')
       COUNT = 0
  62   READ(11,*)JBYS(1),YBO2(1),XPRINT(1),TBCPF(1),TBCP(1)
 5201  FORMAT(20X,I3,10X,F7.4,8X,F7.4,10X,E12.4,11X,E12.4)
       IF (JBYS(1) .EQ. 0) THEN
          COUNT = COUNT + 1
       ENDIF
       IF (COUNT .LT. LSTA) THEN
          GO TO 62
       ELSE
          INC = 2
  47      READ(11,*)JBYS(INC),YBO2(INC),XPRINT(INC)
     +        ,TBCPF(INC),TBCP(INC)
          IF (JBYS(INC) .NE. 0)THEN
            INC = INC + 1
            GO TO 47
          ENDIF
  48   ENDIF
       CLOSE(UNIT = 11)
C ************ CHECKING OUT DATA INPUT ***************
       OPEN(UNIT=32,FILE='PPP.DAT',STATUS='UNKNOWN')
       DO 60 I = 1,INC
          WRITE (32,*)JBYS(I),YBO2(I),XPRINT(I),TBCPF(I),TBCP(I)
 60    CONTINUE
       CLOSE (UNIT=32)
C **************************************************
       OPEN(UNIT=32,FILE='PPP.DAT',STATUS='UNKNOWN')
       DO I = 1,INC-1
```

```
        READ(32,*)JBYS(I),YBO2(I),XPRINT(I),TBCPF(I),TBCP(I)
        XYZ=YBO2(I)
        STP=TBCPF(I)
        STU=TBCP(I)
        YARRY(I)=XYZ
        CP1ARRY(I)=STP
        CP2ARRY(I)=STU
      END DO
      CLOSE (UNIT=32)
      CALL MAXMIN(TBCPF,INC,VALMAX,VALMIN)
      CALL MAXMIN(TBCP,INC,MAX,MIN)
      CALL MAXMIN(YBO2,INC,MAXY,MINY)
C     DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
      L1 = 'CP - FLAT WING$'
      L2 = 'CP - CAMBERED WING$'
C     INITIALIZE THE GRAPHICS SYSTEM
      CALL INIT
C     LABEL X AND Y AXES USING SELF COUNTING STRINGS
      CALL XNAME('Y/B/2$',100)
      CALL YNAME('COEFFICIENT OF PRESSURE$',100)
C     DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
      CALL AREA2D(6.0,8.0)
C     DEFINE HEADING LABEL
      CALL HEADIN('SPANWISE CP DISTRIBUTION$',-100,1.8,1)
C     PLOT ADDITIONAL TICK MARKS
      CALL XTICKS(1)
      CALL YTICKS(1)
C     PACK LEGEND LABELS INTO ARRAY IPACK
      CALL LINES(L1,IPACK,1)
      CALL LINES(L2,IPACK,2)
C     SET UP AXIS
      CALL GRAF(0.,((MAXY-MINY)/5.),MAXY+.1,0.,((VALMAX
     +  -VALMIN)/5.),(VALMAX+.1))
C     FRAME THE SUBPLOT AREA
      CALL FRAME
C     PLOT PRESSURE DISTRIBUTION DATA WITH A THICK LINE AND MARKER 15
      CALL MARKER(15)
      CALL THKCRV(.04)
      CALL CURVE(YARRY,CP1ARRY,INC-1,1)
      CALL MARKER(16)
      CALL RESET('THKCRV')
      CALL DASH
      CALL CURVE(YARRY,CP2ARRY,INC-1,1)
C
C     PLOT MESSAGE
C
      CALL MESSAG('CHORDAL FRACTION(X/L) = $',100,1.,8.25)
      CALL REALNO(CHOFRACT,3,4.25,8.25)
C     CHANGE LEGEND NAME TO "CP DISTRIBUTION"
      CALL MYLEGN('CP CURVES$',100)
C     PLOT LEGEND
      CALL LEGEND(IPACK,2,1.2,6.8)
C     END PLOT
      CALL ENDPL(0)
C     CREATE GRAPHICS METAFILE P1.UIS
```

```
      CALL METAFL(1)
C    TERMINATE PLOT AT END OF PLOTTING SESSION
      CALL DONEPL
      RETURN
      END

      SUBROUTINE GRAPH2(NSTA)
C
C    DEFINE IPACK ARRAY FOR LEGEND
      INTEGER*4 IPACK(35)
      INTEGER JBYS(100)
      INTEGER NSTA,INC,N
      REAL YBO2(100),XPRINT(100),TBCPF(100),TBCP(100)
      REAL Y,X,CPF,CPC
      REAL MAX,MIN,VALMAX,VALMIN,MAXY,MINY,SPAFRACT
      CHARACTER*40 L1,L2
      COMMON /SPAN/SPAFRACT
      DIMENSION XARRY(100),CP1ARRY(100),CP2ARRY(100)
C    READ ELEMENTS OF UNIT 11 INTO ARRAYS TO PLOT
      OPEN(UNIT=11,FILE='SPWPD.DAT',STATUS='OLD')
      INC = 1
  14  READ(11,5201)N,Y,X,CPF,CPC
 5201 FORMAT(20X,I3,10X,F7.4,8X,F7.4,10X,E12.4,11X,E12.4)
      IF (N .EQ. NSTA) THEN
        JBYS(INC)   = N
        YBO2(INC)   = Y
        XPRINT(INC) = X
        TBCPF(INC)  = CPF
     TBCP(INC)   = CPC
        INC = INC + 1
     GO TO 14
      ELSEIF(N.EQ.99) THEN
        GO TO 15
      ELSE
        GO TO 14
      ENDIF
  15  PRINT *, ' '
      CLOSE(UNIT = 11)
C ************ CHECKING OUT DATA INPUT ***************
      OPEN(UNIT=33,FILE='PP.DAT',STATUS='UNKNOWN')
      DO 60 I = 1,INC
         WRITE (33,5201)JBYS(I),YBO2(I),XPRINT(I),TBCPF(I),TBCP(I)
 60   CONTINUE
      CLOSE(UNIT = 33)
C ***************************************************
      OPEN(UNIT=33,FILE='PP.DAT',STATUS='UNKNOWN')
      DO I = 1,INC-1
        READ(33,5201)JBYS(I),YBO2(I),XPRINT(I),TBCPF(I),TBCP(I)
        XYZ=XPRINT(I)
        STP=TBCPF(I)
        STU=TBCP(I)
        XARRY(I)=XYZ
        CP1ARRY(I)=STP
        CP2ARRY(I)=STU
      END DO
      CLOSE (UNIT = 33)
```

```
       CALL MAXMIN(TBCPF,INC,VALMAX,VALMIN)
       CALL MAXMIN(TBCP,INC,MAX,MIN)
       CALL MAXMIN(XPRINT,INC,MAXY,MINY)
C     DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
       L1 = 'CP - FLAT WING$'
       L2 = 'CP - CAMBERED WING$'
C     INITIALIZE THE GRAPHICS SYSTEM
       CALL INIT
C     LABEL X AND Y AXES USING SELF COUNTING STRINGS
       CALL XNAME('(X-XLE)/C$',100)
       CALL YNAME('COEFFICIENT OF PRESSURE$',100)
C     DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
       CALL AREA2D(6.0,8.0)
C     DEFINE HEADING LABEL
       CALL HEADIN('CHORDWISE CP DISTRIBUTION$',-100,1.8,1)
C     PLOT ADDITIONAL TICK MARKS
       CALL XTICKS(1)
       CALL YTICKS(1)
C     PACK LEGEND LABELS INTO ARRAY IPACK
       CALL LINES(L1,IPACK,1)
       CALL LINES(L2,IPACK,2)
C     SET UP AXIS
       CALL GRAF(0.,.2,1.,0.,((VALMAX-VALMIN)/5.),(VALMAX+.1))
C     FRAME THE SUBPLOT AREA
       CALL FRAME
C     PLOT PRESSURE DISTRIBUTION DATA WITH A THICK LINE AND MARKER 15
       CALL MARKER(15)
       CALL THKCRV(.04)
       CALL CURVE(XARRY,CP1ARRY,INC-1,1)
       CALL MARKER(16)
       CALL RESET('THKCRV')
       CALL DASH
       CALL CURVE(XARRY,CP2ARRY,INC-1,1)
C
C     PLOT MESSAGE
C
       CALL MESSAG('SPAN FRACTION(Y/B/2) = $',100,1.,8.25)
       CALL REALNO(SPAFRACT,3,4.25,8.25)
C     CREATE LEGEND NAME OF "CP CURVES"
       CALL MYLEGN('CP CURVES$',100)
C     PLOT LEGEND
       CALL LEGEND(IPACK,2,1.2,6.8)
C     END PLOT
       CALL ENDPL(0)
C     CREATE GRAPHICS METAFILE P2.UIS
       CALL METAFL(2)
C     TERMINATE PLOT AT END OF PLOTTING SESSION
       CALL DONEPL
       RETURN
       END

      SUBROUTINE GRAPH3
C
C     DEFINE IPACK ARRAY FOR LEGEND
      INTEGER*4 IPACK(35)
      REAL XCL(20),DGF(20),TOTAL(20),RDGF(20),RTOTAL(20)
```

```
       REAL MAX,MIN,VALMAX,VALMIN
       CHARACTER*40 L1,L2
       DIMENSION DRAGER(20),TOTA(20)
C     READ ELEMENTS OF UNIT 12 INTO ARRAYS TO PLOT
        OPEN(UNIT=12,FILE='DRAGPO.DAT',STATUS='OLD')
        DO 25 I = 1,20
          READ(12,3529)XCL(I),DGF(I),TOTAL(I),RDGF(I),RTOTAL(I)
 3529   FORMAT(5X,F12.6,2X,F12.6,8X,F12.6,15X,F12.6,10X,F12.6)
 25     CONTINUE
        CLOSE (UNIT = 12)
        DO I = 1,20
          XYZ=DGF(I)
          STU=TOTAL(I)
          DRAGER(I)=XYZ
          TOTA(I)=STU
        END DO
        CALL MAXMIN(DGF,20,VALMAX,VALMIN)
        CALL MAXMIN(TOTAL,20,MAX,MIN)
C     DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
        L1 = 'DRAG POLAR - FLAT WING$'
        L2 = 'DRAG POLAR - CAMBERED WING$'
C     INITIALIZE THE GRAPHICS SYSTEM
        CALL INIT
C     LABEL X AND Y AXES USING SELF COUNTING STRINGS
        CALL XNAME('CD$',100)
        CALL YNAME('CL$',100)
C     DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
        CALL AREA2D(6.0,8.0)
C     DEFINE HEADING LABEL
        CALL HEADIN('DRAG POLAR$',-100,2.,1)
C     PLOT ADDITIONAL TICK MARKS
        CALL XTICKS(1)
        CALL YTICKS(1)
C     PACK LEGEND LABELS INTO ARRAY IPACK
        CALL LINES(L1,IPACK,1)
        CALL LINES(L2,IPACK,2)
C     SET UP AXIS
        CALL GRAF(0.0,0.1,.5,0.,((MAX-MIN)/5.),(MAX+.01))
C     FRAME THE SUBPLOT AREA
        CALL FRAME
C     PLOT PRESSURE DISTRIBUTION DATA WITH A THICK LINE AND MARKER 15
        CALL MARKER(15)
        CALL THKCRV(.04)
        CALL CURVE(XCL,DRAGER,20,1)
        CALL MARKER(16)
        CALL RESET('THKCRV')
        CALL DASH
        CALL CURVE(XCL,TOTA,20,1)
C     CHANGE LEGEND NAME TO "CP DISTRIBUTION"
        CALL MYLEGN('DRAG POLAR CURVES$',100)
C     PLOT LEGEND
        CALL LEGEND(IPACK,2,1.2,6.5)
C     END PLOT
        CALL ENDPL(0)
C     CREATE GRAPHICS METAFILE P3.UIS
```

```
        CALL METAFL(3)
C     TERMINATE PLOT AT END OF PLOTTING SESSION
        CALL DONEPL
        RETURN
        END

       SUBROUTINE GRAPH4
C
C     DEFINE IPACK ARRAY FOR LEGEND
       INTEGER*4 IPACK(35)
       INTEGER LAFT
       REAL XOL(100),XAIRP(100),CLIFTF(100),CLIFT(100)
       REAL MAX,MIN,VALMAX,VALMIN
       COMMON /PLOT4/LAFT
       CHARACTER*40 L1,L2
       DIMENSION CL1ARRY(100),CL2ARRY(100)
C     READ ELEMENTS OF UNIT 13 INTO ARRAYS TO PLOT
        OPEN(UNIT=13,FILE='SWLD.DAT',STATUS='OLD')
        DO 25 I = 1,LAFT-1
          READ(13,862)XOL(I),XAIRP(I),CLIFTF(I),CLIFT(I)
 862      FORMAT(12X,F8.5,2X,F8.3,3X,F9.6,26X,F9.6)
 25     CONTINUE
        CLOSE (UNIT = 13)
C   CHECKING DATA INPUT
        OPEN(UNIT=24,FILE='CHECK.DAT',STATUS='UNKNOWN')
        DO 35 I = 1,LAFT-1
          WRITE(24,862)XOL(I),XAIRP(I),CLIFTF(I),CLIFT(I)
  35    CONTINUE
        CLOSE(UNIT=24)
C
        OPEN(UNIT=24,FILE='CHECK.DAT',STATUS='UNKNOWN')
        DO I = 1,LAFT-1
          READ(24,862)XOL(I),XAIRP(I),CLIFTF(I),CLIFT(I)
          XYZ=CLIFTF(I)
          STP=CLIFT(I)
          CL1ARRY(I)=XYZ
          CL2ARRY(I)=STP
        END DO
        CLOSE (UNIT = 24)
        CALL MAXMIN(CLIFTF,LAFT-1,VALMAX,VALMIN)
        CALL MAXMIN(CLIFT,LAFT-1,MAX,MIN)
C     DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
        L1 = 'LIFT FRACTION - FLAT WING$'
        L2 = 'LIFT FRACTION - CAMBERED WING$'
C     INITIALIZE THE GRAPHICS SYSTEM
        CALL INIT
C     LABEL X AND Y AXES USING SELF COUNTING STRINGS
        CALL XNAME('X/XMAX$',100)
        CALL YNAME('LIFT FRACTION$',100)
C     DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
        CALL AREA2D(6.0,8.0)
C     DEFINE HEADING LABEL
        CALL HEADIN('STREAMWISE LIFT DISTRIBUTION$',-100,1.5,1)
C     PLOT ADDITIONAL TICK MARKS
        CALL XTICKS(1)
        CALL YTICKS(1)
C     PACK LEGEND LABELS INTO ARRAY IPACK
        CALL LINES(L1,IPACK,1)
        CALL LINES(L2,IPACK,2)
C     SET UP AXIS
        CALL GRAF(0.0,0.2,1.,0.,((VALMAX-VALMIN)/5.),(VALMAX+.005))
C     FRAME THE SUBPLOT AREA
        CALL FRAME
C     PLOT PRESSURE DISTRIBUTION DATA WITH A THICK LINE AND MARKER 15
        CALL MARKER(15)
        CALL THKCRV(.04)
        CALL CURVE(XOL,CL1ARRY,LAFT-1,1)
        CALL MARKER(16)
        CALL RESET('THKCRV')
        CALL DASH
        CALL CURVE(XOL,CL2ARRY,LAFT-1,1)
C     CHANGE LEGEND NAME TO "LIFT FRACTION CURVES"
        CALL MYLEGN('LIFT FRACTION CURVES$',100)
C     PLOT LEGEND
        CALL LEGEND(IPACK,2,1.2,6.8)
C     END PLOT
        CALL ENDPL(0)
C     CREATE GRAPHICS METAFILE P4.UIS
        CALL METAFL(4)
C     TERMINATE ˀLOT AT END OF PLOTTING SESSION
        CALL DONEPL
        RETURN
        END

       SUBROUTINE GRAPH5
C
C     DEFINE IPACK ARRAY FOR LEGEND
       INTEGER*4 IPACK(35)
       INTEGER NR
       REAL YB2(100),SLFF(100),SLIFT(100),SDRAG(100)
       REAL MAX,MIN,VALMAX,VALMIN
       COMMON /PLOT5/NR
       CHARACTER*40 L1,L2
       DIMENSION XL1ARRY(100),XL2ARRY(100)
C     READ ELEMENTS OF UNIT 14 INTO ARRAYS TO PLOT
        OPEN(UNIT=14,FILE='SPWLD.DAT',STATUS='OLD')
        DO 45 I = 1,31
          READ(14,865)YB2(I),SLFF(I),SLFF(I),SLIFT(I),SDRAG(I)
 865      FORMAT(17X,F10.6,5X,F11.6,3X,F11.6,10X,F11.6,3X,F11.6)
 45     CONTINUE
        CLOSE (UNIT = 14)
        DO I = 1,31
          XYZ=SLFF(I)
          STP=SLIFT(I)
          XL1ARRY(I)=XYZ
          XL2ARRY(I)=STP
        END DO
C        OPEN(UNIT=25,FILE='CHECKER.DAT',STATUS='UNKNOWN')
C        DO 35 I = 1,31
C          WRITE(25,865)YB2(I),SLFF(I),SLFF(I),SLIFT(I),SDRAG(I)
```

```
C  35    CONTINUE
C        CLOSE(UNIT=25)
        CALL MAXMIN(SLFF,31,VALMAX,VALMIN)
        CALL MAXMIN(SLIFT,31,MAX,MIN)
C     DEFINE AND ASSIGN LEGEND CHARACTER STRINGS
        L1 = 'LIFT FRACTION - FLAT WING$'
        L2 = 'LIFT FRACTION - CAMBERED WING$'
C     INITIALIZE THE GRAPHICS SYSTEM
        CALL INIT
C     LABEL X AND Y AXES USING SELF COUNTING STRINGS
        CALL XNAME('Y/B/2$',100)
        CALL YNAME('LIFT FRACTION$',100)
C     DEFINE PLOT AREA TO BE 6 INCHES BY 8 INCHES
        CALL AREA2D(6.0,8.0)
C     DEFINE HEADING LABEL
        CALL HEADIN('SPANWISE LIFT DISTRIBUTION$',-100,1.3,1)
C     PLOT ADDITIONAL TICK MARKS
        CALL XTICKS(1)
        CALL YTICKS(1)
C     PACK LEGEND LABELS INTO ARRAY IPACK
        CALL LINES(L1,IPACK,1)
        CALL LINES(L2,IPACK,2)
C     SET UP AXIS
        CALL GRAF(0.0,0.2,1.,0.,((VALMAX-VALMIN)/5.),(VALMAX+.005))
C     FRAME THE SUBPLOT AREA
        CALL FRAME
C     PLOT PRESSURE DISTRIBUTION DATA WITH A THICK LINE AND MARKER 15
        CALL MARKER(15)
        CALL THKCRV(.04)
        CALL CURVE(YB2,XL1ARRY,31,1)
        CALL MARKER(16)
        CALL RESET('THKCRV')
        CALL DASH
        CALL CURVE(YB2,XL2ARRY,31,1)
C     CHANGE LEGEND NAME TO "LIFT FRACTION CURVES"
        CALL MYLEGN('LIFT FRACTION CURVES$',100)
C     PLOT LEGEND
        CALL LEGEND(IPACK,2,1.2,6.8)
C     END PLOT
        CALL ENDPL(0)
C     CREATE GRAPHICS METAFILE P5.UIS
        CALL METAFL(5)
C     TERMINATE PLOT AT END OF PLOTTING SESSION
        CALL DONEPL
        RETURN
        END

       SUBROUTINE  MAXMIN(ARRAY,NY,VALMAX,VALMIN)
C
C  ARRAY = THE ARRAY WHICH IS BEING SORTED INTO ASCENDING ORDER
C  NUMBER= THE NUMBER OF ELEMENTS IN THE ARRAY TO BE SORTED
C  VALMAX= LARGEST VALUE IN THE ARRAY
C  VALMIN= SMALLEST VALUE IN THE ARRAY
       REAL VALMAX,VALMIN
       INTEGER NUMBER
       LOGICAL SORTED
```

```
      DIMENSION ARRAY(100)
      SORTED = .FALSE.
      NUMBER = NY
   30 IF (.NOT.SORTED) THEN
         SORTED = .TRUE.
         DO 40 I = 1,NUMBER - 1
           IF(ARRAY(I).GT.ARRAY(I+1))THEN
             VALUE = ARRAY(I)
             ARRAY(I) = ARRAY(I+1)
             ARRAY(I+1) = VALUE
             SORTED = .FALSE.
           ENDIF
   40    CONTINUE
         GO TO 30
      ENDIF
      VALMAX = ARRAY(NUMBER)
      VALMIN = ARRAY(1)
      RETURN
      END

      SUBROUTINE P916AF
C
C     TO COMPUTE CL, ETC, FOR FLAT WING AT ARBITRARY
C     PLANFORM WITH CP UNKNOWN (CONSTANT DZDX)
C     WING DEFINITION IS BY TABLE LOOK-UP, WITH XLE AND
C     XTE STORED AS A FUNCTION OF BETAY, USING THE GRID
C     SYSTEM OF THE CAMBER SURFACE COMPUTING PROGRAM
      DIMENSION TBCP(105,51),TBCPF(105,51)
      DIMENSION DCP(51,2),DCPF(51,2),PHI(51,3),PHIF(51,3)
      DIMENSION TSUM(51),TSUMF(51)
      REAL K1,K2,K3
      INTEGER LAFT,CONSTANT
      DIMENSION TCLIFT(100,2),TSLIFT(51,2)
      DIMENSION TSDRAG(51)
      COMMON TYB2(51),TZORD(26,51),JBYMAX,NON,NOPCT,RATIO,XLEO,XTEO,
     1TPCT(26),TXLE(50),TXTE(50),DZDX,XMAX,CBAR,TDZDX(105,51),XM,NOM,
     2TMACH(5),TZSKAL,REFAR,SPAN,XO,PI,CNPOD,CAPOD,TCNPOD(5),TCAPOD(5)
      COMMON FDZDX,XLEOF,TXLEF(50),NFLAP2,NFLAP1,XMREF
      COMMON TYPEX,NLEX,NTEX,TBLEX(15),TBLEY(15),TBTEX(15),TBTEY(15)
      COMMON IDENT(8)
      COMMON /PLOT4/LAFT
      COMMON /PLOT5/NR
      COMMON /HEALEY/RCL9,RCL9F
      XMREFO=XMREF
      DO 900 IX=1,100
      DO 900 IY=1,51
      TBCP(IX,IY)=0.0
  900 TBCPF(IX,IY)=0.0
      DO 901 NZ=1,100
      TCLIFT(NZ,1)=0.0
  901 TCLIFT(NZ,2)=0.0
      DO 902 IZ=1,51
      TSDRAG(IZ)=0.
      TSLIFT(IZ,1)=0.0
  902 TSLIFT(IZ,2)=0.0
      NSF=0
      REFAR=REFAR/2.0
      ALAIR=XMAX
      NONP1=NON+1
      FNON=FLOAT(NON)
      WRITE (26,742)
      WRITE (62,742)
C     PRINT 742
  742 FORMAT(2X///40X,39H***INPUT DATA IN AIRPLANE DIMENSIONS***)
      WRITE(26,729)IDENT
      WRITE(62,729)IDENT
C     PRINT   729,IDENT
  729 FORMAT(2X/8A10/)
      WRITE(26,726)XM,NON,JBYMAX,NOPCT
      WRITE(62,726)XM,NON,JBYMAX,NOPCT
C     PRINT   726,XM,NON,JBYMAX,NOPCT
  726 FORMAT(2X/20X,2HM=F8.4,10X,4HNON=I4,12X,7HJBYMAX=I4,9X,6HNOPCT=I4)
      WRITE(26,727)XMAX,XLEO,XTEO,SPAN,REFAR,CBAR,XMREFO
      WRITE(62,727)XMAX,XLEO,XTEO,SPAN,REFAR,CBAR,XMREFO
C     PRINT   727,XMAX,XLEO,XTEO,SPAN,REFAR,CBAR,XMREFO
  727 FORMAT(2X/20X,8HXMAX   =F9.4,3X,5HXLEO=F9.4,6X,5HXTEO=F9.4,5X,5HSP
     $AN=F9.4/20X,8HREFAR/2=F9.4,3X,5HCBAR=F9.4,6X,6HXMREF=F9.4)
      WRITE (26,728)
      WRITE (62,728)
C     PRINT 728
  728 FORMAT(2X//50X,4HTPCT,22X,4HTYB2/)
      IF (JBYMAX .LT. NOPCT) GO TO 731
      KLAST=NOPCT
      GO TO 732
  731 KLAST=JBYMAX
  732 DO 750 KPRINT=1,KLAST
C     PRINT 747,KPRINT,TPCT(KPRINT),KPRINT,TYB2(KPRINT)
  750 WRITE (26,747) KPRINT,TPCT(KPRINT),KPRINT,TYB2(KPRINT)
      WRITE (62,747) KPRINT,TPCT(KPRINT),KPRINT,TYB2(KPRINT)
  747 FORMAT(35X,I5,5X,F11.5,4X,I5,5X,F11.5)
      KLAST=KLAST+1
      IF (JBYMAX .EQ. NOPCT) GO TO 736
      IF (JBYMAX .LT. NOPCT) GO TO 734
      DO 735 KPRINT=KLAST,JBYMAX
C     PRINT 745,KPRINT,TYB2(KPRINT)
  735 WRITE (26,745) KPRINT,TYB2(KPRINT)
      WRITE (62,745) KPRINT,TYB2(KPRINT)
  745 FORMAT(62X,I5,4X,F11.5)
      GO TO 736
  734 DO 737 KPRINT=KLAST,NOPCT
C     PRINT 746,KPRINT,TPCT(KPRINT)
  737 WRITE (26,746) KPRINT,TPCT(KPRINT)
      WRITE (62,746) KPRINT,TPCT(KPRINT)
  746 FORMAT(35X,I5,5X,F11.5)
  736 CONTINUE
  610 IF(TYPEX)612,602,612
  612 WRITE(26,613)
      WRITE(62,613)
C     PRINT 613
  613 FORMAT(2X//50X,5HTBLEX,22X,5HTBLEY/)
  614 FORMAT(45X,F11.5,16X,F11.5)
  615 FORMAT(2X//50X,5HTBTEX,22X,5HTBTEY/)
```

```
      DO 617 I=1,NLEX
C     PRINT 614,TBLEX(I),TBLEY(I)
  617 WRITE(26,614)TBLEX(I),TBLEY(I)
      WRITE(62,614)TBLEX(I),TBLEY(I)
      WRITE(26,615)
      WRITE(62,615)
C     PRINT 615
      DO 618 I=1,NTEX
C     PRINT 614,TBTEX(I),TBTEY(I)
  618 WRITE(26,614)TBTEX(I),TBTEY(I)
      WRITE(62,614)TBTEX(I),TBTEY(I)
      KC=1
      KB=1
      YACC =0.0
      YDEL= SPAN/(2.*(FLOAT(NON)))
      DO 660 N=1,NON
      YACC=YACC + YDEL
  630 DELXL = TBLEX(KB +1) - TBLEX(KB)
      DELYL= TBLEY(KB+1)-TBLEY(KB)
      IF(TBLEY(KB+1)-YACC)634,644,644
  634 IF(N-NON)636,638,638
  636 KB=KB+1
  637 GO TO 630
  638 TXLE(N) = TBLEX(NLEX)
      TXTE(N) = TBTEX(NTEX)
      GO TO 660
  644 TXLE(N) =TBLEX(KB)+(DELXL/DELYL)*(YACC-TBLEY(KB))
  646 DELXT = TBTEX(KC+1) - TBTEX(KC)
      DELYT = TBTEY(KC+1) -TBTEY(KC)
      IF(TBTEY(KC+1)-YACC)650,652,652
  650 KC = KC+1
      GO TO 646
  652 TXTE(N) = TBTEX(KC)+(DELXT/DELYT)*(YACC-TBTEY(KC))
  660 CONTINUE
  602 CONTINUE
      WRITE (26,752)
      WRITE (62,752)
C     PRINT 752
  752 FORMAT(2X//34X,1HN15X,4HTXLE23X,4HTXTE/)
      DO 760 J=1,NON
C     PRINT 753,J,TXLE(J),TXTE(J)
  760 WRITE (26,753) J,TXLE(J),TXTE(J)
      WRITE (62,753) J,TXLE(J),TXTE(J)
  753 FORMAT(30X,I5,11X,F11.6,16X,F11.6)
      WRITE (26,769)
C     PRINT 769
  769 FORMAT(2X///20X,24HTABLE OF ORDINATES,TZORD//20X,4HNOTE/23X,81HFOR
     $ EACH PERCENT CHORD VALUE PRINTED BELOW , THE TABLE OF ORDINATES W
     $HICH FOLLOWS/20X,67HCORRESPONDS TO SPAN POSITIONS GIVEN IN THIS TA
     $BLE OF SPAN-FRACTIONS//53X,31HTABLE OF SPAN-FRACTIONS , Y/B/2)
      WRITE(26,770)(TYB2(J),J=1,JBYMAX)
C     PRINT   770,(TYB2(J),J=1,JBYMAX)
      WRITE(26,774)
C     PRINT   774
  774 FORMAT(2X//5X,13HPERCENT CHORD,45X,11HZ-ORDINATES)
      DO 771 J=1,NOPCT
      WRITE(26,772)TPCT(J)
C     PRINT   772,TPCT(J)
  772 FORMAT(2X,/,8X,F7.3)
C     PRINT 770,(TZORD(J,K),K=1,JBYMAX)
  771 WRITE (26,770)  (TZORD(J,K),K=1,JBYMAX)
  770 FORMAT(19X,10(1X,F9.4))
      NR=NON+100
      DZDXF=-.01746
      MUPR=NOM+1
      DO 790 JDO=1,MUPR
      BETA=SQRT(XM**2-1.0)
      SF=FLOAT(NON)/(BETA*SPAN/2.0)
      IF(TZSKAL)1113,1112,1113
 1113 RESKAL=TZSKAL
      TZSKAL=0
      GO TO 1111
 1112 IF(JDO-1)704,705,704
  704 BETPRE=BETA
      XM=TMACH(JDO-1)
      CNPOD=TCNPOD(JDO-1)
      CAPOD=TCAPOD(JDO-1)
      WRITE(26,706)XM
C     PRINT   706,XM
  706 FORMAT(1H1,40X,30H***WING RESCALED FOR MACH NO. F8.5///)
      BETA=SQRT(XM**2-1.0)
      SF=FLOAT(NON)/(BETA*SPAN/2.0)
      RESKAL=BETPRE/BETA
      RATIO=RATIO/RESKAL
      XLEO=XLEO*RESKAL
      XTEO=XTEO*RESKAL
      XMAX=XMAX*RESKAL
      CBAR=CBAR*RESKAL
      XMREF=XMREF*RESKAL
      DO 720 JSKAL=1,NON
      TXLE(JSKAL)=TXLE(JSKAL)*RESKAL
  720 TXTE(JSKAL)=TXTE(JSKAL)*RESKAL
 1111 DO 730 KSKAL=1,JBYMAX
      DO 730 NSKAL=1,NOPCT
  730 TZORD(NSKAL,KSKAL)=TZORD(NSKAL,KSKAL)*RESKAL
  705 IF (NSF .NE. 0) GO TO 739
      DO 60 KSF=1,NON
      TXLE(KSF)=TXLE(KSF)*SF
   60 TXTE(KSF)=TXTE(KSF)*SF
      DO 61 KSFC=1,JBYMAX
      DO 61 KSFR=1,NOPCT
   61 TZORD(KSFR,KSFC)=TZORD(KSFR,KSFC)*SF
      CBAR=CBAR*SF
      XLEO=XLEO*SF
      XTEO=XTEO*SF
      XMAX=XMAX*SF
      XMREF=XMREF*SF
      NSF=1
  739 WRITE (26,62)
C     PRINT 62
   62 FORMAT(2X///40X,38H***INPUT DATA IN PROGRAM DIMENSIONS***)
```

```
      WRITE(26,729)IDENT
C     PRINT   729,IDENT
      WRITE(26,726)XM,NON,JBYMAX,NOPCT
C     PRINT   726,XM,NON,JBYMAX,NOPCT
      WRITE(26,63)XMAX,XLEO,XTEO,NON,CBAR,XMREF
C     PRINT   63,XMAX,XLEO,XTEO,NON,CBAR,XMREF
   63 FORMAT(2X/20X,8HXMAX    =F9.4,3X,5HXLEO=F9.4,6X,5HXTEO=F9.4,5X,5HSP
     $AN=I5/40X,5HCBAR=F9.4,6X,6HXMREF=F9.4)
      WRITE (26,752)
C     PRINT 752
      DO 64 JSF=1,NON
C     PRINT 753,JSF,TXLE(JSF),TXTE(JSF)
   64 WRITE (26,753) JSF,TXLE(JSF),TXTE(JSF)
      WRITE (26,769)
C     PRINT 769
      WRITE(26,770)(TYB2(J),J=1,JBYMAX)
C     PRINT   770,(TYB2(J),J=1,JBYMAX)
      WRITE(26,774)
C     PRINT   774
      DO 773 J=1,NOPCT
      WRITE(26,772)TPCT(J)
C     PRINT   772,TPCT(J)
C     PRINT   770, (TZORD(J,K),K=1,JBYMAX)
  773 WRITE(26,770)(TZORD(J,K),K=1,JBYMAX)
C
      IF (XMAX .LE. 100.) GO TO 4001
      WRITE (26,4000) XMAX,XM
C     PRINT 4000,XMAX,XM
 4000 FORMAT (/68H SORRY XMAX CAN NOT EXCEED 100.  PROGRAM WILL CONTINUE
     1 TO NEXT CASE./15X,5HXMAX=E16.8,10X,5HMACH=E16.8//)
      GO TO 790
 4001 CALL SLOPE
      IF (FDZDX .EQ. 0.0) GO TO 7373
      KI=0
   70 IF(NFLAP1)73,71,73
   71 XLEOF=XLEOF*SF
      LEOF = INT(XLEOF + 1.0)
      LTEOF5 = INT(XTEO+5.0)
      DO 72 L=LEOF,LTEOF5
   72 TDZDX(L,1) =FDZDX
      JFLAPS = 2
      JFLAP = 1
      GO TO 74
   73 JFLAPS = NFLAP1 + 1
      JFLAP = NFLAP1
   74 DO 77 I = JFLAP,NFLAP2
      KI=KI+1
      XLEF=TXLEF(KI)*SF
      LEF = INT(XLEF + 1.0)
      XTE=TXTE(I)
      LTEF5 = INT(XTE + 5.0)
      DO 76 L = LEF,LTEF5
   76 TDZDX(L,JFLAPS)= FDZDX
      JFLAPS = JFLAPS + 1
   77 CONTINUE
   78 FORMAT(1H0//,5X,34HFLAP OPTION INCLUDED, FLAP SLOPE =F11.6//)
```

```
      WRITE(26,78)FDZDX
 7373 LMAX=INT(XMAX+1.)
      DRAG=0
      ALIFT=0
      PMOM=0
      ALIFTF=0.
      PMOMF=0.
      DFOC=0.
      BETA=SQRT(XM**2-1.0)
      B4=4.0/BETA
      PI1=1.0/PI
      NL=200-NR
C
      XMU=0.5
      DO 5024 IY=1,51
      TSUM(IY)=0.
 5024 TSUMF(IY)=0.
C     WRITE(26,5202)
 5202 FORMAT(2X///37X,46H***CALCULATED LIFTING PRESSURE DISTRIBUTION***)
C     WRITE(26,729)IDENT
C     WRITE(26,726)XM,NON,JBYMAX,NOPCT
    9 DO 110 LSOP1=1,LMAX
C
      LSTAR=LSOP1
      DO 5000 LSOP2=1,2
      IF(LSOP2.EQ.2)LSTAR=LSOP1+1
      IF(LSOP2.EQ.1)GO TO 10
      DO 5025 IY=1,51
      TSUM (IY)=0.
 5025 TSUMF(IY)=0.
   10 DO 100 NSTAR=100,NR
      JBYS=NSTAR-100
      IF(JBYS)12,11,12
   11 XSTE=XTEO
      XSLE=XLEO
      GO TO 13
   12 XSLE=TXLE(JBYS)
      XSTE=TXTE(JBYS)
   13 LSLE=INT(XSLE+1.0)
      IF(LSLE-LSTAR)15,15,100
   15 LSTE=INT(XSTE+1.0)
      LSTE4=LSTE
      IF(LSTAR-LSTE4)17,17,100
   17 SUM=0.
      SUMF=0.
      IF(LSOP2.EQ.2)GO TO 5026
      SUM =TSUM (JBYS+1)
      SUMF=TSUMF(JBYS+1)
 5026 CONTINUE
      IF(LSTAR-1)18,56,18
   18 DO 55 N=NL,NR
      NDELTN=NSTAR-N
      NDIFF=IABS(NDELTN)
      LMACH=LSTAR-NDIFF
      JBY=IABS(N-100)
      IF(JBY)38,37,38
   37 XLE=XLEO
      XTE=XTEO
      GO TO 39
   38 XLE=TXLE(JBY)
      XTE=TXTE(JBY)
   39 LLE=INT(XLE+1.0)
      LTE=INT(XTE+1.)
      IF(LLE-LMACH)45,45,55
   45 DELTN1=FLOAT(NDELTN)+.5
      DELTN2=DELTN1-1.0
      LAST=LMACH
      IF(LTE.LE.LMACH)LAST=LTE
      LSTART=LLE
      IF(LSOP2.EQ.2)GO TO 5027
      LSTART=LSTAR-1
      IF(LSTART.GT.LAST)GO TO 55
 5027 CONTINUE
      DO 54 LVAR=LSTART,LAST
      NS1=LSTAR-LVAR
      DELTL=FLOAT(NS1)+.5
      SQDL=DELTL**2
      TERM1=(SQRT(SQDL-DELTN1**2))/DELTN1
      TERM2=(SQRT(SQDL-DELTN2**2))/DELTN2
      R=(TERM2-TERM1)/DELTL
      IF(LLE.EQ.LTE)GO TO 5021
      IF(LVAR.EQ.LLE)GO TO 48
      IF(LVAR.EQ.LTE)GO TO 5022
      GO TO 51
 5021 R=R*(XTE-XLE)
      GO TO 51
 5022 ATE=XTE-FLOAT(LTE-1)
      R=R*ATE
      GO TO 51
   48 ALE=FLOAT(LLE)-XLE
      R=ALE*R
   51 JCP=JBY+1
      CPF=TBCPF(LVAR,JCP)
      SUMF=SUMF+R*CPF
      CP=TBCP(LVAR,JCP)
      SUM=SUM+R*CP
      IF(LSOP2.EQ.1)GO TO 54
      IF(LVAR.GT.(LSTAR-2))GO TO 54
      TSUM (JBYS+1)=TSUM (JBYS+1)+R*CP
      TSUMF(JBYS+1)=TSUMF(JBYS+1)+R*CPF
   54 CONTINUE
   55 CONTINUE
   56 JCP=JBYS+1
      DZDX=TDZDX(LSTAR,JCP)
      CPAFT=-B4*DZDX+PI1*SUM
      CPAFTF=-B4*DZDXF+PI1*SUMF
      DCP(JCP,LSOP2)=CPAFT
      DCPF(JCP,LSOP2)=CPAFTF
      TBCP(LSTAR,JCP)=CPAFT
      TBCPF(LSTAR,JCP)=CPAFTF
  100 CONTINUE
 5000 CONTINUE
C
C     WRITE(26,5200)LSOP1
 5200 FORMAT(2X//15X,6HLSTAR=I4/20X,5HNSTAR,10X,5HY/B/2,9X,9H(X-XLE)/C,7
     $X,13HCP(FLAT WING),17X,17HCP(CAMBERED WING))
 5008 CONTINUE
C
C
      DO 5020 NSTAR=100,NR
      JBYS=NSTAR-100
      YBO2=FLOAT(JBYS)/FNON
      JCPS=JBYS+1
      LSTAR=LSOP1
      IF(JBYS)5002,5001,5002
 5001 XSLE=XLEO
      XSTE=XTEO
      GO TO 5003
 5002 XSLE=TXLE(JBYS)
      XSTE=TXTE(JBYS)
 5003 LSLE=INT(XSLE+1.)
      LSTE=INT(XSTE+1.)
      IF(LSTAR.LT.LSLE)GO TO 5020
      IF(LSTAR.GT.LSTE)GO TO 5020
      IF(LSTAR.EQ.LSTE)GO TO 5023
      IF(LSTAR.EQ.LSLE)GO TO 5005
 5006 A1=1.0
      GO TO 5007
 5005 PHI(JCPS,3)=0.0
      PHIF(JCPS,3)=0.0
      A1=FLOAT(LSTAR)-XSLE
 5007 CONTINUE
      A2=1.
      PHI(JCPS,1)=PHI(JCPS,3)-.25*DCP(JCPS,1)*A1
      PHIF(JCPS,1)=PHIF(JCPS,3)-.25*DCPF(JCPS,1)*A1
      PHI (JCPS,2)=PHI (JCPS,1)-.25*DCP (JCPS,2)*A2
      PHIF(JCPS,2)=PHIF(JCPS,1)-.25*DCPF(JCPS,2)*A2
      ABSA1=ABS(1.-A1)
      IF(ABSA1.GT..0001)GO TO 5010
      K1=XMU
      K2=.5*(1.-XMU)
      K3=K2
      GO TO 5011
 5010 K1=XMU
      K3=(1.-XMU)/(A1+1.)
      K2=A1*K3
 5011 PHI3=K2*PHI(JCPS,2)+K1*PHI(JCPS,1)+K3*PHI(JCPS,3)
      PHI3F=K2*PHIF(JCPS,2)+K1*PHIF(JCPS,1)+K3*PHIF(JCPS,3)
      TBCP(LSTAR,JCPS)=-4.0*(PHI3-PHI(JCPS,3))/A1
      TBCPF(LSTAR,JCPS)=-4.0*(PHI3F-PHIF(JCPS,3))/A1
C
 5023 CONTINUE
      CHORD=XSTE-XSLE
      IF(CHORD.LT..001)GO TO 5009
      IF(LSTAR.EQ.LSTE)GO TO 5009
      XPRINT=(FLOAT(LSTAR)-XSLE)/CHORD
      GO TO 5012
 5009 XPRINT=1.0
 5012 CONTINUE
      WRITE(26,5201)JBYS,YBO2,XPRINT,TBCPF(LSTAR,JCPS),TBCP(LSTAR,JCPS)
      WRITE(11,5201)JBYS,YBO2,XPRINT,TBCPF(LSTAR,JCPS),TBCP(LSTAR,JCPS)
 5201 FORMAT(20X,I3,10X,F7.4,8X,F7.4,10X,E12.4,11X,E12.4)
      IF(LSTAR.EQ.LSTE)GO TO 5020
C
      PHI(JCPS,3)=PHI3
      PHIF(JCPS,3)=PHI3F
 5020 CONTINUE
  110 CONTINUE
      AREA9=0.
      ALIFT9=0
      DRAG9=0
      PMOM9=0
      DFOC9=0.
      ALFF9=0.
      PMOM9F=0.
      LAFT=LMAX
      DO 355 LIFT=1,LAFT
      TCLIFT(LIFT,1)=0.
  355 TCLIFT(LIFT,2)=0.
      DO 400 N=100,NR
      JBY=N-100
      JCP=JBY+1
      IF(JBY)301,300,301
  300 XLE=XLEO
      XTE=XTEO
      GO TO 305
  301 XLE=TXLE(JBY)
      XTE=TXTE(JBY)
  305 LLE=INT(XLE+1.0)
      LTE=INT(XTE+1.0)
      ALE=FLOAT(LLE)-XLE+.5
      TSLIFT(JCP,1)=0.
      TSLIFT(JCP,2)=0.
 2001 FORMAT(1H0//)
      KWIT=0
      DO 370 LSTAR=LLE,LTE
C                                 ************
C       ***            FORCE INTEGRATION USING               ***
C       ***CP=.75*TBCP(LSTAR,JCP) + .25*TBCP(LSTAR+1,JCP)***
C        ***DZDX=.75*TDZDX(LSTAR) + .25*TDZDX(LSTAR-1)    ***
C       ***CP AND DZDX CONSTANT BETWEEN BLOCK CENTERS     ***
C                                 ************
      IF(KWIT.NE.0)GO TO 370
      IF(LLE.EQ.LTE)GO TO 407
      IF(LLE.EQ.(LTE-1))GO TO 408
      IF(LSTAR.EQ.LLE)GO TO 410
      IF(LSTAR.GE.(LTE-1))GO TO 411
      GO TO 413
  407 ABLOCK=XTE-XLE
      CP9 =TBCP (LSTAR,JCP)
      CP9F=TBCPF(LSTAR,JCP)
      XLS=.5*(XLE + XTE)
      DZDX=TDZDX(LSTAR,JCP)
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    GO TO 414
408 XCHECK=FLOAT(LTE)-.5
    IF(XTE.LE.XCHECK)GO TO 415
    IF(LSTAR.EQ.LLE)GO TO 410
409 ABLOCK=XTE-FLOAT(LTE)+.5
    XLS=.5*(XTE + XCHECK)
    GO TO 414
410 ABLOCK=ALE
    CP9 =.75*TBCP (LSTAR,JCP) + .25*TBCP (LSTAR+1,JCP)
    CP9F=.75*TBCPF(LSTAR,JCP) + .25*TBCPF(LSTAR+1,JCP)
    XLS=.5*(FLOAT(LLE) + XLE)
    DZDX=TDZDX(LSTAR,JCP)
    GO TO 325
411 XCHECK=FLOAT(LTE)-.5
    IF(XTE.LE.XCHECK)GO TO 412
    IF(LSTAR.EQ.LTE) GO TO 416
    GO TO 413
412 ABLOCK=XTE-FLOAT(LTE)+1.5
    CP9 =.75*TBCP (LSTAR,JCP) + .25*TBCP (LSTAR+1,JCP)
    CP9F=.75*TBCPF(LSTAR,JCP) + .25*TBCPF(LSTAR+1,JCP)
    DZDX=.75*TDZDX(LSTAR,JCP)+.25*TDZDX(LSTAR-1,JCP)
    XLS=0.5*(XTE + FLOAT(LTE) - 1.5)
    GO TO 414
413 ABLOCK=1.0
    CP9 =.75*TBCP (LSTAR,JCP) + .25*TBCP (LSTAR+1,JCP)
    CP9F=.75*TBCPF(LSTAR,JCP) + .25*TBCPF(LSTAR+1,JCP)
    DZDX=.75*TDZDX(LSTAR,JCP)+.25*TDZDX(LSTAR-1,JCP)
    XLS=FLOAT(LSTAR)
    GO TO 325
415 ABLOCK=XTE-XLE
    CP9 =.75*TBCP (LSTAR,JCP) + .25*TBCP (LSTAR+1,JCP)
    CP9F=.75*TBCPF(LSTAR,JCP) + .25*TBCPF(LSTAR+1,JCP)
    DZDX=TDZDX(LSTAR,JCP)
    XLS=.5*(XLE +XTE)
    GO TO 414
416 ABLOCK=XTE - FLOAT(LTE) + .5
    XLS=.5*(XTE +XCHECK)
    GO TO 414
414 KWIT=1
325 IF(JBY.EQ.0)ABLOCK=ABLOCK*.5
    IF(N.EQ.NR) ABLOCK=ABLOCK*.5
    AREA9=AREA9 + ABLOCK
340 CONTINUE
    FORCE=CP9*ABLOCK
    FORCEF=CP9F*ABLOCK
    ALIFT9=ALIFT9+FORCE
    ALFF9=ALFF9+FORCEF
    DRAG9=DRAG9-FORCE*DZDX
    DFOC9=DFOC9-FORCEF*DZDX
    PMOM9=PMOM9-FORCE*XLS
    PMOM9F=PMOM9F-FORCEF*XLS
    TCLIFT(LSTAR,1)=TCLIFT(LSTAR,1)+FORCE
    TCLIFT(LSTAR,2)=TCLIFT(LSTAR,2)+FORCEF
    TSDRAG(JCP)=TSDRAG(JCP)-FORCE*DZDX
    TSLIFT(JCP,1)=TSLIFT(JCP,1)+FORCE
    TSLIFT(JCP,2)=TSLIFT(JCP,2)+FORCEF
```

```
  370 CONTINUE
  400 CONTINUE
      SAREA9=AREA9/BETA
      WRITE(26,3511)
      WRITE(62,3511)
C     PRINT 3511
 3511 FORMAT(2X////30X,61H*****CALCULATED WING OVERALL AERODYNAMIC CHARA
     $CTERISTICS*****/)
      WRITE(26,729)IDENT
      WRITE(62,729)IDENT
C      PRINT   729,IDENT
      WRITE(26,726)XM,NON,JBYMAX,NOPCT
      WRITE(62,726)XM,NON,JBYMAX,NOPCT
C     PRINT   726,XM,NON,JBYMAX,NOPCT
      WRITE(26,3543)
      WRITE(62,3543)
C     PRINT 3543
 3543 FORMAT(2X//30X,12HPROGRAM AREA,35X,14HREFERENCE AREA)
      WRITE(26,3544)
      WRITE(62,3544)
C     PRINT   3544
 3544 FORMAT(2X/23X,9HFLAT WING,10X,13HCAMBERED WING,14X,9HFLAT WING,
     $12X,13HCAMBERED WING)
 3545 FORMAT(1X/12X,2HCL,1X,E17.8,6X,E17.8,6X,E17.8,8X,E17.8)
 3547 FORMAT(1X/12X,2HCD,1X,E17.8,6X,E17.8,6X,E17.8,8X,E17.8)
 3549 FORMAT(1X/12X,2HCM,1X,E17.8,6X,E17.8,6X,E17.8,8X,E17.8)
 3551 FORMAT(1X/12X,4HAREA,14X,E17.8,32X,E17.8)
      CHANGE = SAREA9/(SF**2*REFAR)
      CL9= ALIFT9/AREA9
      CD9= DRAG9/AREA9
      CMAP9= PMOM9/(AREA9 * CBAR)
      CL9F= ALFF9/AREA9
      CD9F= -CL9F * DZDXF
      CMAP9F = PMOM9F/(AREA9*CBAR)
      RCMP9F = CMAP9F * CHANGE
      RCMAP9 = CMAP9 * CHANGE
      RCL9= CL9 * CHANGE
      RCD9= CD9 * CHANGE
      RCL9F = CL9F *CHANGE
      RCD9F = CD9F * CHANGE
      WRITE(26,3545)CL9F,CL9,RCL9F,RCL9
      WRITE(62,3545)CL9F,CL9,RCL9F,RCL9
C     PRINT   3545,CL9F,CL9,RCL9F,RCL9
      WRITE(26,3547)CD9F,CD9,RCD9F,RCD9
      WRITE(62,3547)CD9F,CD9,RCD9F,RCD9
C     PRINT   3547,CD9F,CD9,RCD9F,RCD9
      WRITE(26,3549)CMAP9F,CMAP9,RCMP9F,RCMAP9
      WRITE(62,3549)CMAP9F,CMAP9,RCMP9F,RCMAP9
C     PRINT   3549,CMAP9F,CMAP9,RCMP9F,RCMAP9
      WRITE(26,3551)SAREA9,REFAR
      WRITE(62,3551)SAREA9,REFAR
C     PRINT   3551,SAREA9,REFAR
      CDFOC9 = DFOC9/AREA9
      CDCOF9 = -CL9 * DZDXF
      CDINT = (CDCOF9 +CDFOC9)/CL9F
      CDOCL2 = -DZDXF/CL9F
      RCDCL2 = CDOCL2/CHANGE
      XCL = -.02
 3525 FORMAT(2X//12X,18HPOLAR,PROGRAM AREA,7X,4HCD =F10.6,3H + F10.6,6H(
     $ CL -F10.6,3H) +F10.6,6H( CL -F10.6,4H)**2)
      WRITE(26,3525)CD9,CDINT,CL9,CDOCL2,CL9
      WRITE(62,3525)CD9,CDINT,CL9,CDOCL2,CL9
C     PRINT   3525,CD9,CDINT,CL9,CDOCL2,CL9
 3526 FORMAT(2X/12X,20HPOLAR,REFERENCE AREA5X,4HCD =F10.6,3H + F10.6,6H(
     $ CL -F10.6,3H) +F10.6,6H( CL -F10.6,4H)**2)
C     PRINT 3526,RCD9,CDINT,RCL9,RCDCL2,RCL9
      WRITE (26,3526)RCD9,CDINT,RCL9,RCDCL2,RCL9
      WRITE (62,3526)RCD9,CDINT,RCL9,RCDCL2,RCL9
      WRITE(26,3543)
      WRITE(62,3543)
C     PRINT   3543
      WRITE(26,3528)
      WRITE(62,3528)
C     PRINT   3528
 3528 FORMAT(2X/12X,2HCL,7X,12HCD,FLAT WING,6X,16HCD,CAMBERED WING,13X,
     $12HCD,FLAT WING,8X,16HCD,CAMBERED WING)
      DO 3530 KCL = 1,20
      XCL = XCL +.02
      DELTCL =  XCL - CL9
      DELCL2 = DELTCL **2
      XINT = CDINT * DELTCL
      XFLAT = CDOCL2 * DELCL2
      TOTAL = CD9 + XINT + XFLAT
      DGF = CDOCL2 * (XCL**2)
      RDELCL = XCL - RCL9
      RDLCL2 = RDELCL **2
      RXINT = CDINT * RDELCL
      RXFLAT = RCDCL2 * RDLCL2
      RTOTAL = RCD9 + RXINT + RXFLAT
      RDGF = RCDCL2 *(XCL**2)
 3529 FORMAT(5X,F12.6,2X,F12.6,8X,F12.6,15X,F12.6,10X,F12.6)
C     PRINT 3529,XCL,DGF,TOTAL,RDGF,RTOTAL
      WRITE (12,3529)XCL,DGF,TOTAL,RDGF,RTOTAL
      WRITE (62,3529)XCL,DGF,TOTAL,RDGF,RTOTAL
 3530 WRITE (26,3529)XCL,DGF,TOTAL,RDGF,RTOTAL
 3532 FORMAT(2X///12X,39HTRANSFORMED POLAR,REFERENCE AREA,  CD =F10.6,
     $3H + ,F10.6,6H (CL -,F10.6,4H)**2)
      CONSTANT = 99
      SST = 0.0000
      STT = 0.0000
      STU = 0.0000E-00
      STV = 0.0000E-00
      WRITE(11,5201)CONSTANT,SST,STT,STU,STV
      CLOSE(UNIT=11)
      CLOSE(UNIT=12)
      RCLMNT = RCL9 - (CDINT/(2.*RCDCL2))
      RCDMNT = RCD9 - (CDINT**2)/(4.*RCDCL2)
      WRITE (26,3532)RCDMNT,RCDCL2,RCLMNT
      WRITE (62,3532)RCDMNT,RCDCL2,RCLMNT
C     PRINT 3532,RCDMNT,RCDCL2,RCLMNT
      XMPRIM=XMREF/CBAR
      X1XMP=-RCMP9F/RCL9F
      X2XMP=X1XMP-XMPRIM
      CMO =RCMAP9+(X1XMP*RCL9)
      WRITE(26,3400)XMREFO,CMO,X2XMP
      WRITE(62,3400)XMREFO,CMO,X2XMP
C     PRINT 3400,XMREFO,CMO,X2XMP
 3400 FORMAT(2X/12X,28HMOMENT COEFFICIENT ABOUT X= ,F10.5,11H ,    CM =
     $,F12.6,3H - ,F12.6,5H * CL)
      WRITE(26,3401)RCL9,RCL9F
      WRITE(62,3401)RCL9,RCL9F
C     PRINT 3401,RCL9,RCL9F
 3401 FORMAT(2X/12X,18HLIFT CURVE , CL = ,F10.5,3H + ,F10.5,8H * ALPHA)
      IF(CNPOD)880,890,880
  880 RCDMNP = RCD9 + CAPOD
      RCINTP =(CDINT + CNPOD*RCDCL2)/(1.-CAPOD * RCDCL2)
      RCDC2P = RCDCL2/((1.-CAPOD*RCDCL2)**2)
 3533 FORMAT(1H0/,5X,52HPOLAR INCLUDING POD INTERFERENCE EFFECTS (REF. A
     1REA))
      WRITE (26,3533)
      WRITE (62,3533)
      CLOINT = CNPOD + RCL9
 3534 FORMAT(1H0,10X,4HCD =F10.6,2H +F10.6,6H (CL -F10.6,4H) + F10.6,6H
     1(CL -F10.6,4H)**2)
 3535 FORMAT(1H0,10X,7HCNPOD =F12.6,15X,7HCAPOD =F12.6)
      WRITE (26,3535)CNPOD,CAPOD
      WRITE(26,3534)RCDMNP,RCINTP,CLOINT,RCDC2P,CLOINT
      WRITE(26,3536)
      WRITE(62,3535)CNPOD,CAPOD
      WRITE(62,3534)RCDMNP,RCINTP,CLOINT,RCDC2P,CLOINT
      WRITE(62,3536)
 3536 FORMAT(1H0,15X,2HCL,15X,2HCD)
      XCL = -.02
      DO 888 KCLI = 1,20
      XCL = XCL + .02
      DCLINT = XCL-CLOINT
      DCLIN2 = DCLINT **2
      CDPINT = RCDMNP + (RCINTP * DCLINT) + (RCDC2P * DCLIN2)
 3537 FORMAT(8X,F12.6,5X,F12.6)
      WRITE(62,3537)XCL,CDPINT
  888 WRITE(26,3537)XCL,CDPINT
 3538 FORMAT(//5X,64HTRANSFORMED POLAR INCLUDING POD INTERFERENCE EFFECT
     1S (REF. AREA))
      WRITE(26,3538)
      WRITE(62,3538)
      CDMIN = RCD9 +CAPOD -(1./(4.*RCDCL2))*((CDINT + CNPOD*RCDCL2)**2)
      CKINT = RCDCL2/((1.-(CAPOD * RCDCL2))**2)
      CLCDMN=RCL9+CNPOD-(1./(2.*RCDCL2))*(1.-CAPOD*RCDCL2)*(CDINT+(CNPOD
     1*RCDCL2))
      WRITE(26,3532)CDMIN,CKINT,CLCDMN
      WRITE(62,3532)CDMIN,CKINT,CLCDMN
C
C                             ***WRITE STREAMWISE LIFT DISTRIBUTION**
C
  890 WRITE(26,860)
      WRITE(62,860)
  860 FORMAT(2X///46X,28HSTREAMWISE LIFT DISTRIBUTION,//39X,9HFLAT WING,
     $25X,13HCAMBERED WING,//36X,4HLIFT,31X,4HLIFT
     $,25X,6HCAMBER,/15X,6HX/XMAX,4X,6HX + XO,3X,8HFRACTION,5X,
     $9HSUMMATION,13X,8HFRACTION,5X,9HSUMMATION,10X,4HAREA)
      SUML=0.0
      SOF=0.0
      KWIT=0
      DO 870 LEN=1,LAFT
      IF(KWIT.EQ.1)GO TO 870
      XOL=FLOAT(LEN)/XMAX
      XOLM=(FLOAT(LEN)+.5)/XMAX
      IF(XOLM.LT.1.0)GO TO 871
      KWIT=1
      XOLM=1.
      IF(XOL.GT.1.)XOL=1.
  871 CONTINUE
      XAIRP=XO + XOL*ALAIR
      XAIRPM=XO+XOLM*ALAIR
      IF(ALIFT9.EQ.0.)CLIFT=TCLIFT(LEN,1)
      IF(ALIFT9.EQ.0.) GO TO 852
      CLIFT=TCLIFT(LEN,1)/ALIFT9
  852 IF(ALFF9.EQ.0.)CLIFTF=TCLIFT(LEN,2)
      IF(ALFF9.EQ.0.) GO TO 854
      CLIFTF=TCLIFT(LEN,2)/ALFF9
  854 SUML=SUML+CLIFT
      SOF=SOF+CLIFTF
      CAMAREA=BETA/2.0*RCL9*2.0*REFAR*(SUML-SOF)
      WRITE(62,862)XOL,XAIRP,CLIFTF,CLIFT
      WRITE(62,8625)XOLM,XAIRPM,SOF,SUML,CAMAREA
      WRITE(26,862)XOL,XAIRP,CLIFTF,CLIFT
      WRITE(13,862)XOL,XAIRP,CLIFTF,CLIFT
  870 WRITE(26,8625)XOLM,XAIRPM,SOF,SUML,CAMAREA
  862 FORMAT(12X,F8.5,2X,F8.3,3X,F9.6,26X,F9.6)
 8625 FORMAT(12X,F8.5,2X,F8.3,16X,F9.6,26X,F9.6,6X,F11.6)
      CLOSE(UNIT=13)
C
C                                ***WRITE SPANWISE LIFT DISTRIBUTION**
C
      WRITE (62,863)
      WRITE (26,863)
  863 FORMAT(2X///42X,36HSPANWISE LIFT AND DRAG DISTRIBUTIONS//,39X,
     $9HFLAT WING,25X,13HCAMBERED WING,/,36X,4HLIFT,10X,4HDRAG,17X,
     $4HLIFT10X,4HDRAG,/,20X,5HY/B/2,9X,8HFRACTION,6X,
     $8HFRACTION,13X,8HFRACTION,6X,8HFRACTION)
      BY=-1.0
      BYTIP=FLOAT(NON)
      JCP=0
      FLNON=FLOAT(NON)
      DO 875 NSPAN=100,NR
      BY=BY+1.0
      JCP=JCP+1
      YB2=BY/BYTIP
      IF(ALIFT9.EQ.0.)SLIFT=TSLIFT(JCP,1)
      IF(ALIFT9.EQ.0.) GO TO 840
      SLIFT=TSLIFT(JCP,1)/ALIFT9
  840 IF(ALFF9.EQ.0.)SLFF=TSLIFT(JCP,2)
      IF(ALFF9.EQ.0.) GO TO 842
      SLFF=TSLIFT(JCP,2)/ALFF9
  842 IF(DRAG9.EQ.0.)SDRAG=TSDRAG(JCP)
      IF(DRAG9.EQ.0.) GO TO 875
      SDRAG=TSDRAG(JCP)/DRAG9
      WRITE(14,865)YB2,SLFF,SLFF,SLIFT,SDRAG
      WRITE(62,865)YB2,SLFF,SLFF,SLIFT,SDRAG
      WRITE(26,865)YB2,SLFF,SLFF,SLIFT,SDRAG
  875 CONTINUE
  865 FORMAT(17X,F10.6,5X,F11.6,3X,F11.6,10X,F11.6,3X,F11.6)
      CLOSE(UNIT = 14)
      IF(ALFF9.EQ.0.)THEN
        WRITE(26,3519)
        WRITE(62,3519)
      ENDIF
      IF(ALIFT9.EQ.0.)THEN
        WRITE(26,3520)
        WRITE(62,3520)
      ENDIF
      IF(DRAG9.EQ.0.)THEN
        WRITE(26,3521)
        WRITE(62,3521)
      ENDIF
 3519 FORMAT(2X/15X,56HSINCE CL AND CD FOR FLAT WING ARE ZERO THE DISTRI
     $BUTIONS/9X,26HARE NOT IN FRACTIONAL FORM)
 3520 FORMAT(2X/15X,56HSINCE CL FOR CAMBERED WING IS ZERO THE LIFT DISTR
     $IBUTION/9X,25HIS NOT IN FRACTIONAL FORM)
 3521 FORMAT(2X/15X,56HSINCE CD FOR CAMBERED WING IS ZERO THE DRAG DISTR
     $IBUTION/9X,25HIS NOT IN FRACTIONAL FORM)
  790 CONTINUE
  500 RETURN
      END

      SUBROUTINE QUERY(NANS)
C
C  ROUTINE TO TRAP ERRORS CAUSED BY IMPROPER RESPONSES TO QUESTIONS.
C  THE COMPUTER GENERATES AND ERROR WHEN A CHARACTER IS SUPPLIED TO
C  A QUESTION EXPECTING AN INTEGER OR REAL VALUE.
C
      NQTEST=0
    1 CONTINUE
      IF (NQTEST .GT. 0) THEN
         PRINT *, '  CHARACTER VALUES ARE NOT VALID.'
         PRINT *, '  PLEASE ENTER AN INTEGER VALUE.'
      END IF
      NQTEST = NQTEST + 1
      READ (5,*,ERR=1)NANS
      RETURN
      END

      SUBROUTINE SLOPE
C
C     TO OBTAIN THE STREAMWISE SLOPE,DZDX,IN ALL BLOCKS OF A WING
C     PLANFORM GRID FOR A CAMBERED WING SURFACE - LINEAR INTERPOLATION
C     BETWEEN INPUT POINTS
      COMMON TYB2(51),TZORD(26,51),JBYMAX,NON,NOPCT,RATIO,XLEO,XTEO,
     1TPCT(26),TXLE(50),TXTE(50),DZDX,X[illegible],CBAR,TDZDX(105,51),XM,NOM,
     2TMACH(5),TZSKAL,REFAR,SPAN,XO,PI,CNPOD,CAPOD,TCNPOD(5),TCAPOD(5)
```

```
      COMMON FDZDX,XLEOF,TXLEF(50),NFLAP2,NFLAP1,ZMAX,IDDI
      DIMENSION TFY(26,51),TCHORD(26,3),BYNON(51),ZZMAX(51),IN(2),
     1IXM(4),IYM(3),TZZ(26)
      DO 1 KF=1,26
      DO 1 NF=1,51
    1 TFY(KF,NF)=0.0
      DO 2 KC=1,26
      DO 2 NC=1,3
    2 TCHORD(KC,NC)=0.0
      MAX=NON+1
      FNON=FLOAT(NON)
C
C     SPANWISE INTERPOLATION ALONG CONSTANT
C     PERCENT CHORD LINES
C
      DO 130 JSPAN=1,NOPCT
      PCC=TPCT(JSPAN)
      Y1=0.0
      Y2=FNON*TYB2(2)
      FY1=TZORD(JSPAN,1)
      FY2=TZORD(JSPAN,2)
      C2=(FY1-FY2)/(Y1-Y2)
      C1=0.5*(FY1+FY2-C2*(Y1+Y2))
      JCOL=0
      JUPR=INT(Y2)+1
      DO 120 KOL=1,JUPR
      JCOL=JCOL+1
      BY=FLOAT(JCOL)-1.0
      FY=C1+C2*BY
      FYR=FY*RATIO
  120 TFY(JSPAN,JCOL)=FY
      JBY1=1
      JLAST=JBYMAX-2
      DO 130 JCUL=1,JLAST
      JBY1=JBY1+1
      JBY2=JBY1+1
      Y1=FNON*TYB2(JBY1)
      Y2=FNON*TYB2(JBY2)
      FY1=TZORD(JSPAN,JBY1)
      FY2=TZORD(JSPAN,JBY2)
      C2=(FY1-FY2)/(Y1-Y2)
      C1=0.5*(FY1+FY2-C2*(Y1+Y2))
      IF(JCUL-JLAST)122,121,122
  121 Y2=FNON+0.5
  122 BYTEST=BY+1.0
      IF(BYTEST-Y2)124,124,130
  124 JCOL=JCOL+1
      BY=BYTEST
      ZFY=C1+C2*BY
      ZFYR=ZFY*RATIO
      TFY(JSPAN,JCOL)=ZFY
      GO TO 122
  130 CONTINUE
C     WRITE(26,902)
  902 FORMAT(2X///41X,38H***PROGRAM GENERATED GEOMETRIC DATA***/)
C
```

```
C       CHORDWISE INTERPOLATION ALONG CONSTANT SPANWISE N VALUES.
C       SURFACE SLOPES DZDX CALCULATED.
C
      DO 160 JCOL=1,MAX
      JBY=JCOL-1
      YBO2=FLOAT(JBY)/FNON
C     WRITE(26,1000)JBY,YBO2
 1000 FORMAT(2X//15X,2HN=I3,5X,29HSPAN STATION, Y/B/2 = N/NON =F8.5//22X
     $,1HL,9X,1HX,7X,5HX-XLE,7X,1HZ,17X,1HX,7X,5HX-XLE,5X,4HDZDX/)
      IF(JBY)132,131,132
  131 XLE=XLEO
      XTE=XTEO
      GO TO 133
  132 XLE=TXLE(JBY)
      XTE=TXTE(JBY)
  133 LLE=INT(XLE)+1
      LTE=INT(XTE)+1
      CHORD=XTE-XLE
      IF(LLE-LTE)134,152,134
  134 PCT1=TPCT(1)*.01
      PCT2=TPCT(2)*0.01
      Y1=PCT1*CHORD
      Y2=PCT2*CHORD
      FY1=TFY(1,JCOL)
      FY2=TFY(2,JCOL)
      C2=(FY1-FY2)/(Y1-Y2)
      C1=0.5*(FY1+FY2-C2*(Y1+Y2))
      TCHORD(1,1)=C1
      TCHORD(1,2)=C2
      TCHORD(1,3)=Y2+XLE
      JX1=1
      LAST=NOPCT-2
      DO 136 LINK=1,LAST
      JX1=JX1+1
      JX2=JX1+1
      PCT1=TPCT(JX1)*0.01
      PCT2=TPCT(JX2)*0.01
      Y1=PCT1*CHORD
      Y2=PCT2*CHORD
      FY1=TFY(JX1,JCOL)
      FY2=TFY(JX2,JCOL)
      C2=(FY1-FY2)/(Y1-Y2)
      C1=0.5*(FY1+FY2-C2*(Y1+Y2))
      JROW=LINK+1
      TCHORD(JROW,1)=C1
      TCHORD(JROW,2)=C2
      TCHORD(JROW,3)=Y2+XLE
  136 CONTINUE
      JROW=1
      KWIT=0
      DO 157 L=LLE,LTE
      XVAR=FLOAT(L)+0.5
      IF(L.GE.LTE-1) GO TO 142
      GO TO 139
  142 IF(LLE.EQ.LTE-1)GO TO 143
      GO TO 138
 143 XVPRE=XLE
     ZPRE=TFY(1,JCOL)
     Z=TFY(NOPCT,JCOL)
     KWIT=1
     X1=XVPRE
     GO TO 140
 138 XVPRE=XVAR-1.0
     ZPRE=Z
     Z=TFY(NOPCT,JCOL)
     KWIT=1
     X1=XVPRE
     GO TO 140
 139 XTEST=TCHORD(JROW,3)
     IF(XTEST-XVAR)141,145,145
 141 JROW=JROW+1
     GO TO 139
 145 C1=TCHORD(JROW,1)
     C2=TCHORD(JROW,2)
     IF(L-LLE)147,146,147
 146 ZPRE=TFY(1,JCOL)
     XLGTH=XVAR-XLE
     X1=XLE
     GO TO 148
 147 ZPRE=Z
     X1=FLOAT(L)-.5
 148 XPM=XVAR-XLE
     Z=C1+C2*XPM
 140 DZDX=Z-ZPRE
     IF(KWIT)151,150,151
 150 IF(L.EQ.LLE) GO TO 149
     GO TO 155
 149 DZDX=DZDX/XLGTH
     GO TO 155
 151 ATE=XTE-XVPRE
     IF(ATE)169,168,169
 168 DZDX=0.0
     GO TO 155
 169 DZDX=DZDX/ATE
 155 TDZDX(L,JCOL)=DZDX
     XP1=X1-XLE
     X2=FLOAT(L)
     XP2=X2-XLE
     ZPRINT=ZPRE
C    WRITE(26,1001)L,X1,XP1,ZPRINT,X2,XP2,DZDX
1001 FORMAT(20X,I4,3X,F9.4,1X,F9.4,1X,F9.4,9X,F9.4,1X,F9.4,2X,F9.4)
 905 IF(KWIT)405,157,405
 405 DO 406 LAD=1,6
 406 TDZDX(L+LAD,JCOL)=DZDX
     L6=L+6
     GO TO 160
 157 CONTINUE
 152 IF(CHORD.LE..001)GO TO 153
     GO TO 154
 153 DZDX=0.0
     GO TO 156
 154 ZLE=TFY(1,JCOL)
```

```
      ZTE=TFY(NOPCT,JCOL)
      DZDX=(ZTE-ZLE)/CHORD
  156 TDZDX(LLE,JCOL)=DZDX
      L=LLE
      X1=XLE
      XP1=X1-XLE
      ZPRINT=TFY(1,JCOL)
      X2=XTE
      XP2=X2-XLE
C     WRITE(26,1001)L,X1,XP1,ZPRINT,X2,XP2,DZDX
      DO 408 LAD=1,5
  408 TDZDX(LLE+LAD,JCOL)=DZDX
      L5=LLE + 5
  160 CONTINUE
  500 RETURN
      END
```

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